



Two component micro injection moulding for moulded interconnect devices

2k moulding for MIDs

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Two component micro injection moulding for moulded interconnect devices (MIDs)

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DTU



Polymetal conference
DTU, 26 Nov 2008

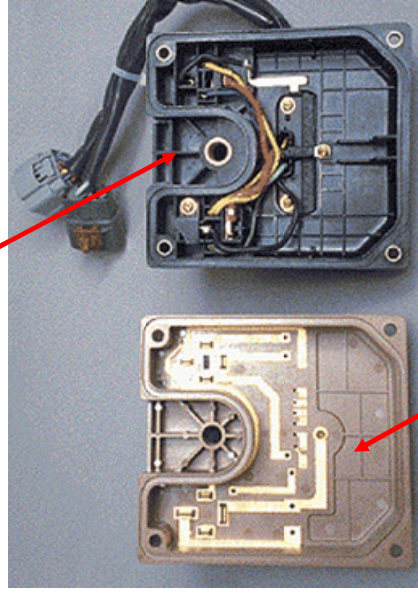
Outline

- **Introduction to MIM**
- **MIM by 2k moulding**
 - Polymer-polymer bond strength
 - Polymer-polymer interface
- **Selective metallization**
- **Demonstrator MIM**
- **Summary and conclusion**

Moulded Interconnect Device (MID)

The MID is an injection moulded plastic part integrating electrical and mechanical functionalities on a single device.

Conventional design



MID module

Pros and cons of MIDs

Pros:

- **Three dimensional circuit pattern**
- **Reduced number of part components**
- **Less assembly operation**
- **Reduced production cost**

Cons:

- **Requires expensive machines and tools**
- **Not suitable for small production volume**
- **Shortage of knowhow**

Application of MIDs

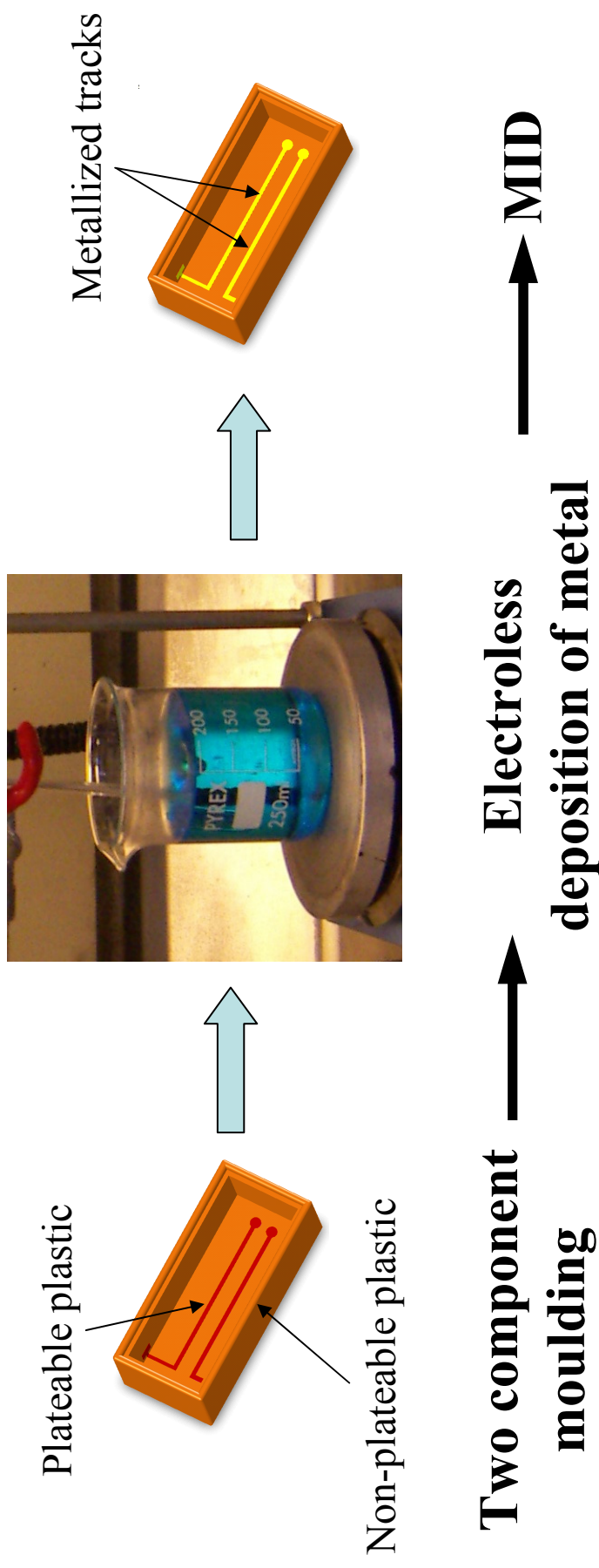
- **Mobile phone** (antenna, housing, sockets)
- **Automotive applications** (door locking mechanism, dashboard switches, multifunctional steering wheel, turbocharger regulator, seat adjuster and sun hood opener)
- **Air plane industry** (no smoking illumination sign, pressure and flow sensors for air-conditioning, automatic overload detection mechanism)
- **Smart pen, Hearing aid, Flipchip**

MID process chains

Circuit structuring methods

			Polymer processing methods					
			Laser structuring	PVD	Metallization	Hot press		
1k moulding								
1 a	1	Laser makes the circuit pattern	2	Electroless deposition of metal	3			
1 b	1	PVD covers the whole surface with metal	2	Laser removes metal from unwanted areas	3			
1 c	1	Electrical structures are directly hot pressed on to the 3D polymer surface	2				2	
2k moulding								
2 a	1	Plateable and non-plateable polymers are combined by 2k moulding followed by electroless metal deposition	2				2	
2 b	1	Injection moulding combines two plastics, laser activates plateable plastic	2	Electroless deposition of metal	3			
Insert moulding								
3 a	1	Metallic circuit structures are used as inserts						
3 b	1	Flexible polymer foils with printed circuit pattern are used as inserts						

Two component injection moulding for MIDs



Two component (2k) injection moulding

-Combine two different polymers

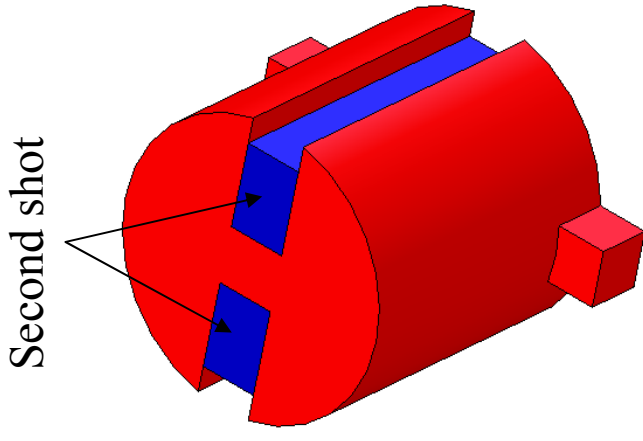
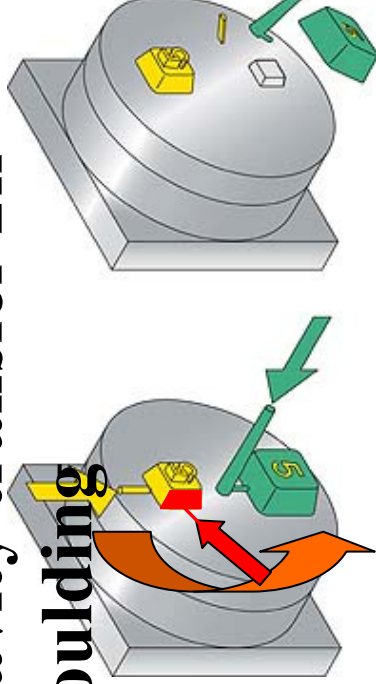
-Variant of 2k moulding :

- Simultaneous

First shot

• Cavity transfer

-Cavity transfer 2k moulding



Source: www.arburg.com

First cavity

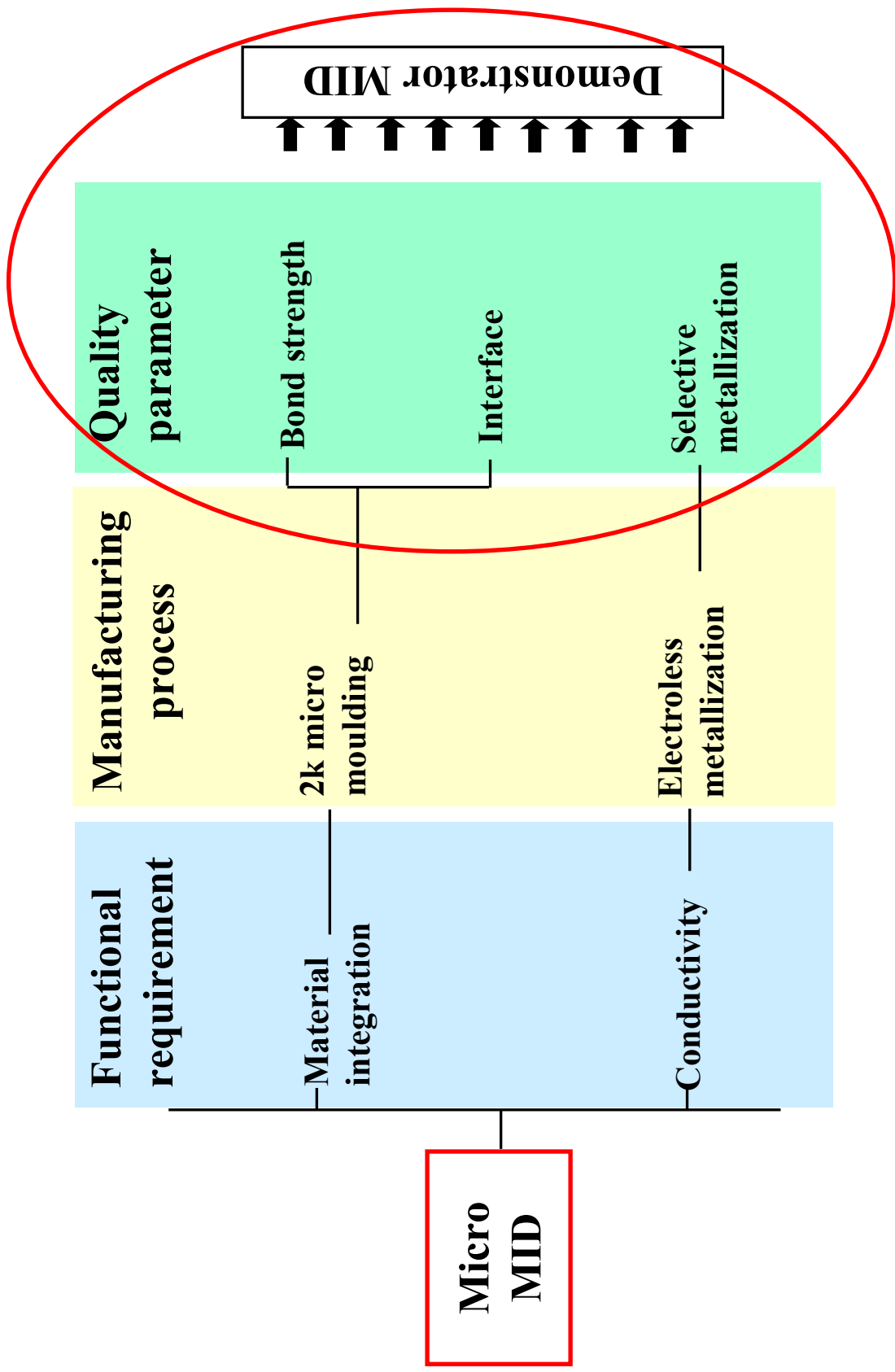
Second cavity

Challenges of 2k moulding

- Reasonable adhesion between the two polymers**
- Well-defined interfaces between the two polymers**

More for MIDs...

- Selective metallization**
- Micro scale selective metallization**



Investigation of the polymer-polymer bond strength

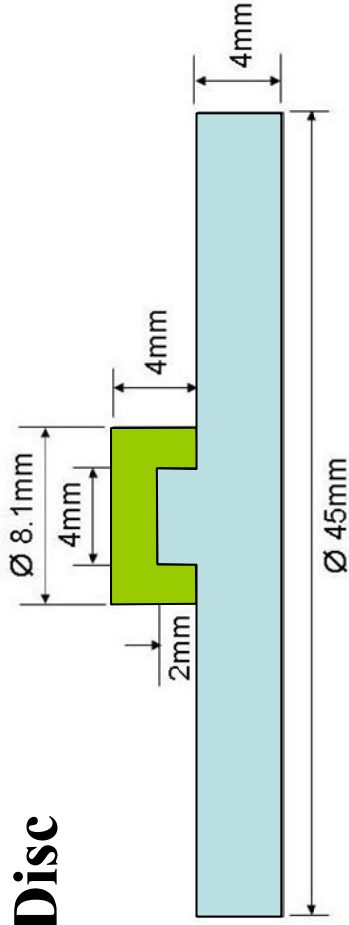
- Suitable polymer pairs for 2k applications**
- Factors influencing bond strength**

Material list

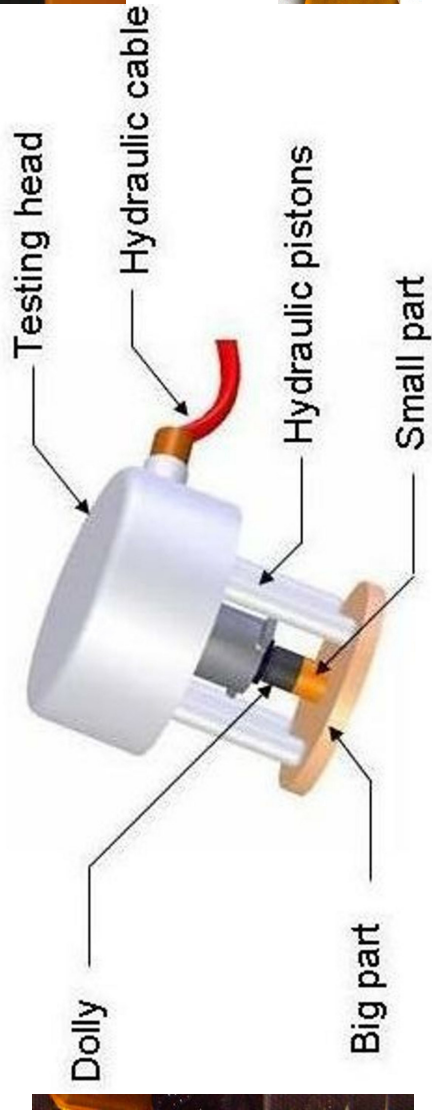
No	Name	Abbreviation	Trade name	Grade	Manufacturer
1	Polyetherimide	PEI	Ultem	1000	GE
2	Polyetherimide	PEI	Ultem	2312EPR	GE
3	Polyetheretherketone	PEEK	Victrex	150GL30	Victrex
4	Polyoxymethylene	POM	Hostaform	C27021	Ticona
5	Liquid crystal polymer	LCP	Vectra	E820i	Ticona
6	Liquid crystal polymer	LCP(Pd)	Vectra	E820i Pd	Ticona
7	Liquid crystal polymer	LCP(LDS)	Vectra	E820i LDS	Ticona
8	Polybutylen terephthalate	PBT	Pocan	DP7102	Lanxess
9	Polybutylen terephthalate	PBT	Vestodur	GF30FR LDS	Degussa
10	Polyphenyleneether blends	(PPE+PA+GF)	Noryl	GTX810	GE
11	Polyphenyleneether blends	(PPE+PA)	Noryl	GTX964	GE
12	Polyphenyleneether blends	(PPE+HIPS)	Noryl	GFN1520V	GE
13	Polystyrene	PS	Polystyrol	143E	BASF
14	Polystyrene	PS	Polystyrol	158K	BASF
15	Polystyrene	PS	Polystyrol	158KGf30	BASF
16	Acrylonitrilebutadienestyrene	ABS	Terluran	997VE	BASF
17	Polycarbonate	PC	Lexan	500R	GE

Polymer-polymer bond strength investigation

2k tensile bar
2k Disc



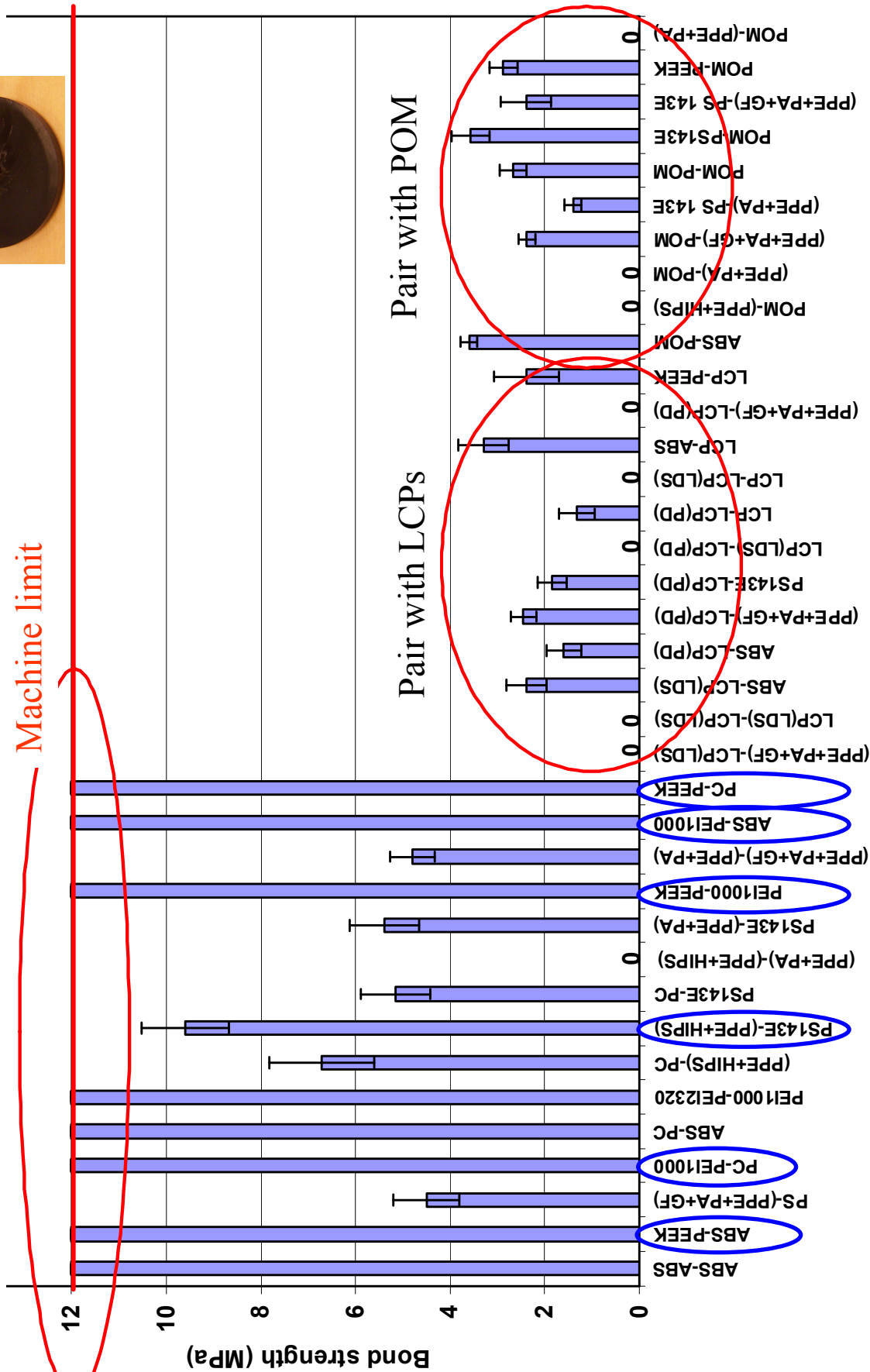
First shot part (small part)
Second shot part (big part)



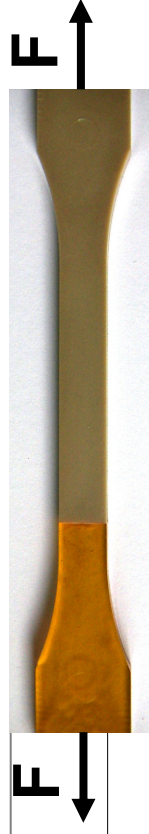
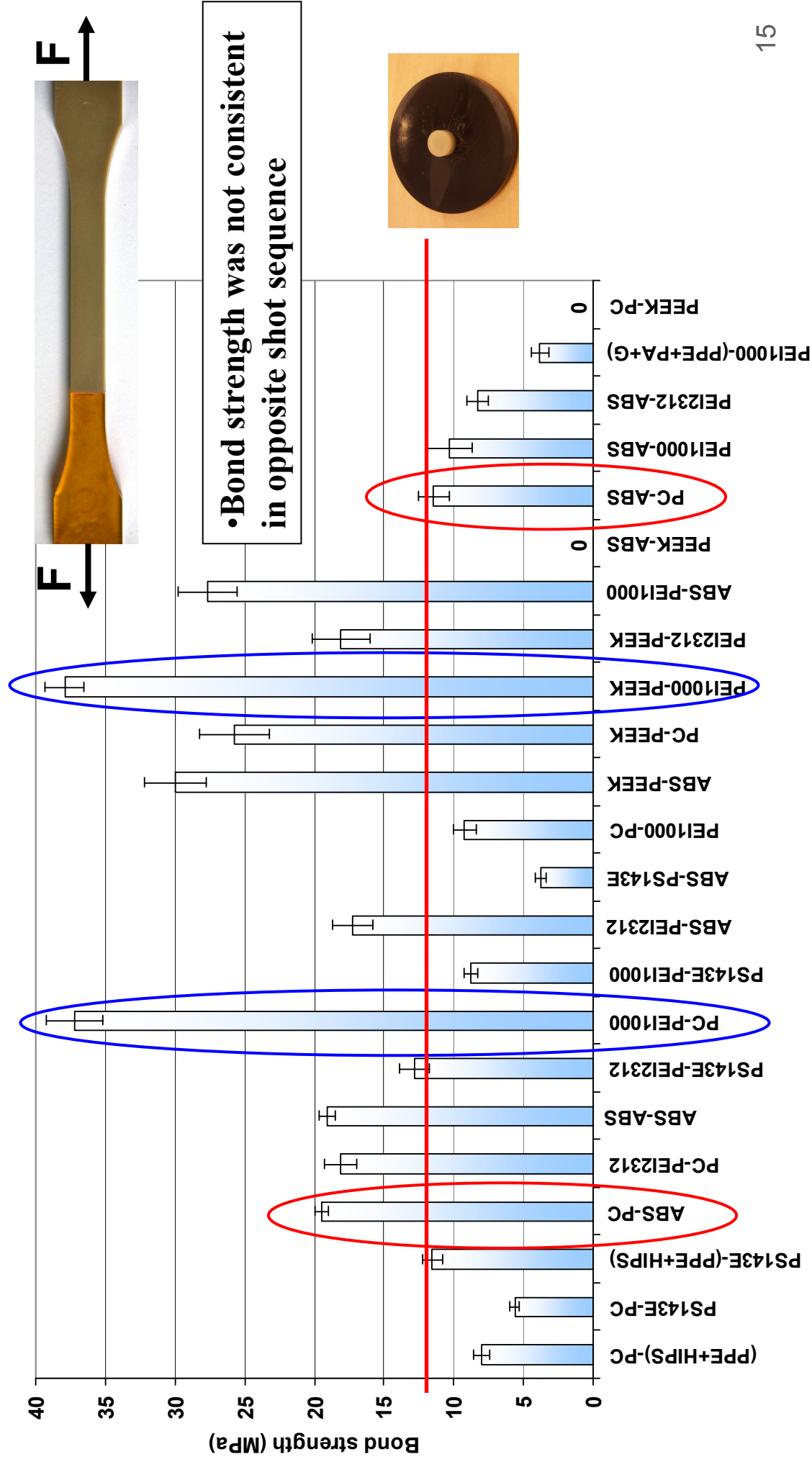
Pull test results



Machine limit



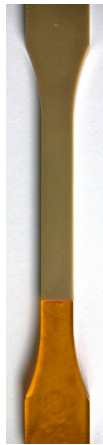
Tensile test results (2k tensile bar)



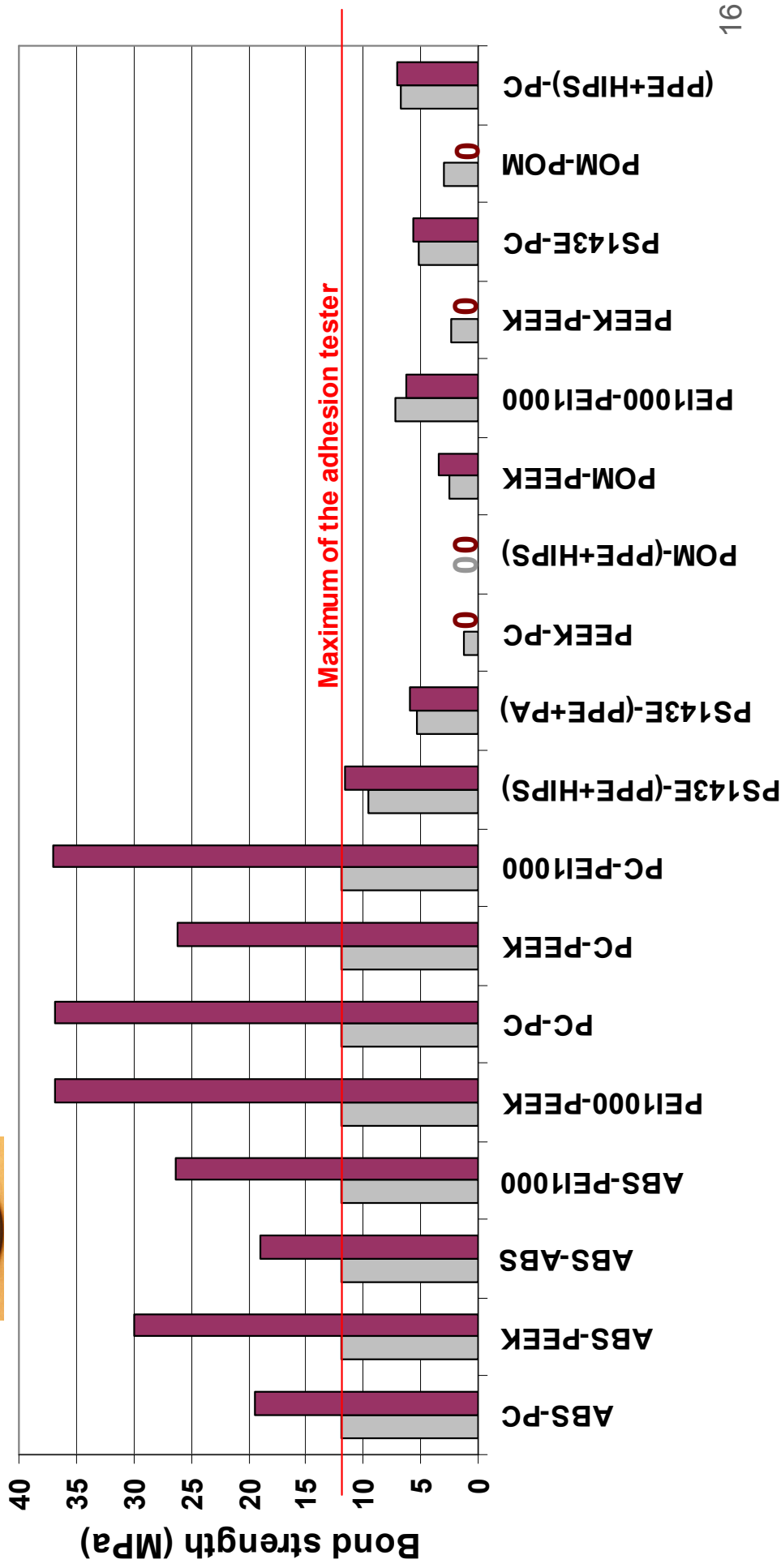
Comparative bond strength



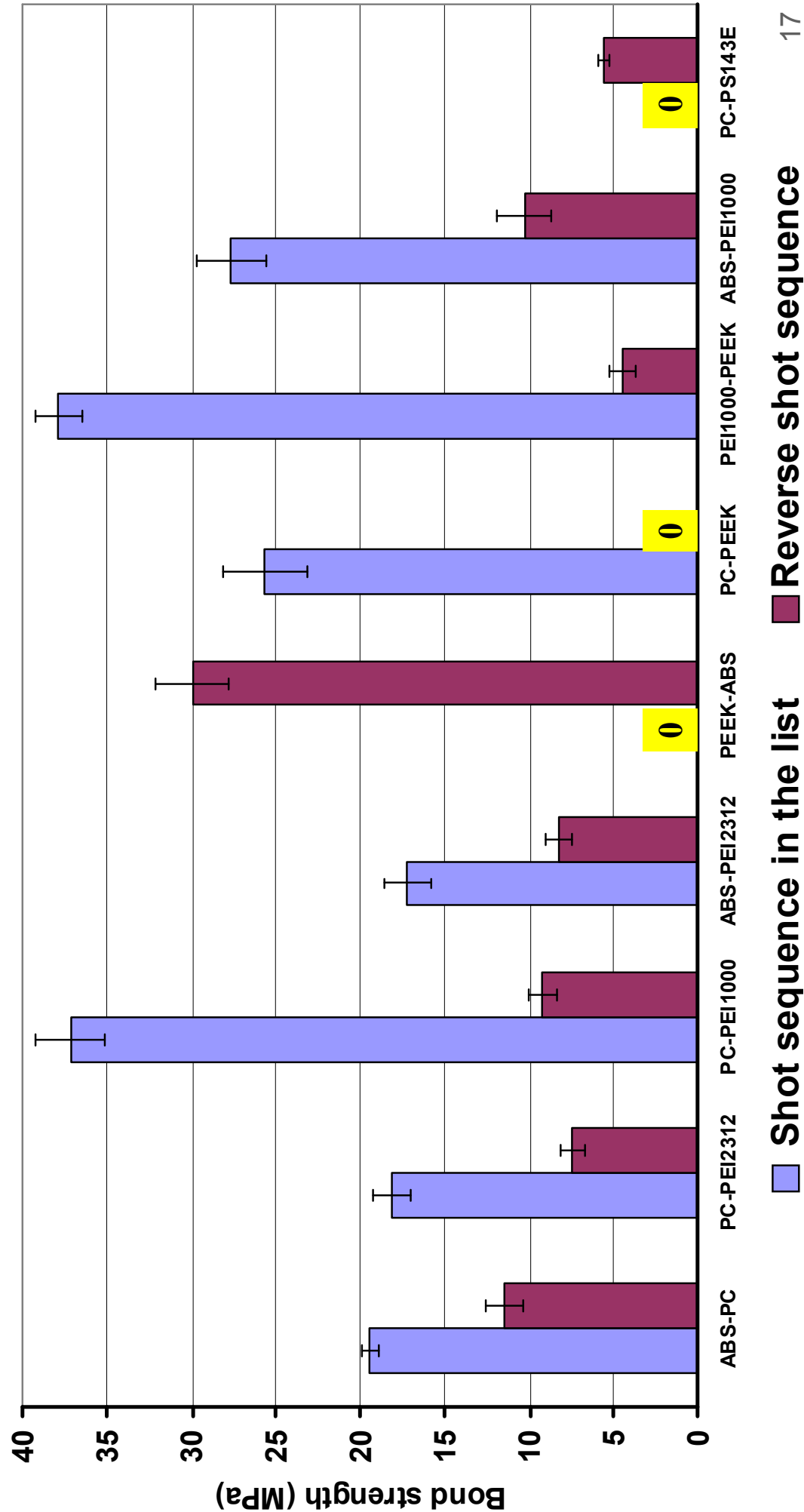
2k Discs



2k Tensile bar



Bond strength as a function of shot sequences



Bond strength as a function of shot sequences

PEEK-PEI1000

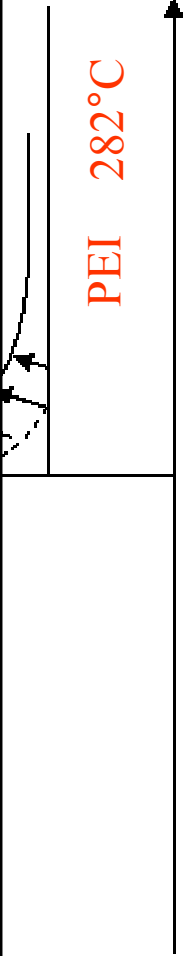
PEI1000-PEEK

First shot	Second shot	Bond strength (MPa)
PEEK	PEI1000	4
PEI1000	PEEK	37

PEEK

First shot	Second shot	Bond strength (MPa)
PEEK	PEI1000	4
PEI1000	PEEK	37

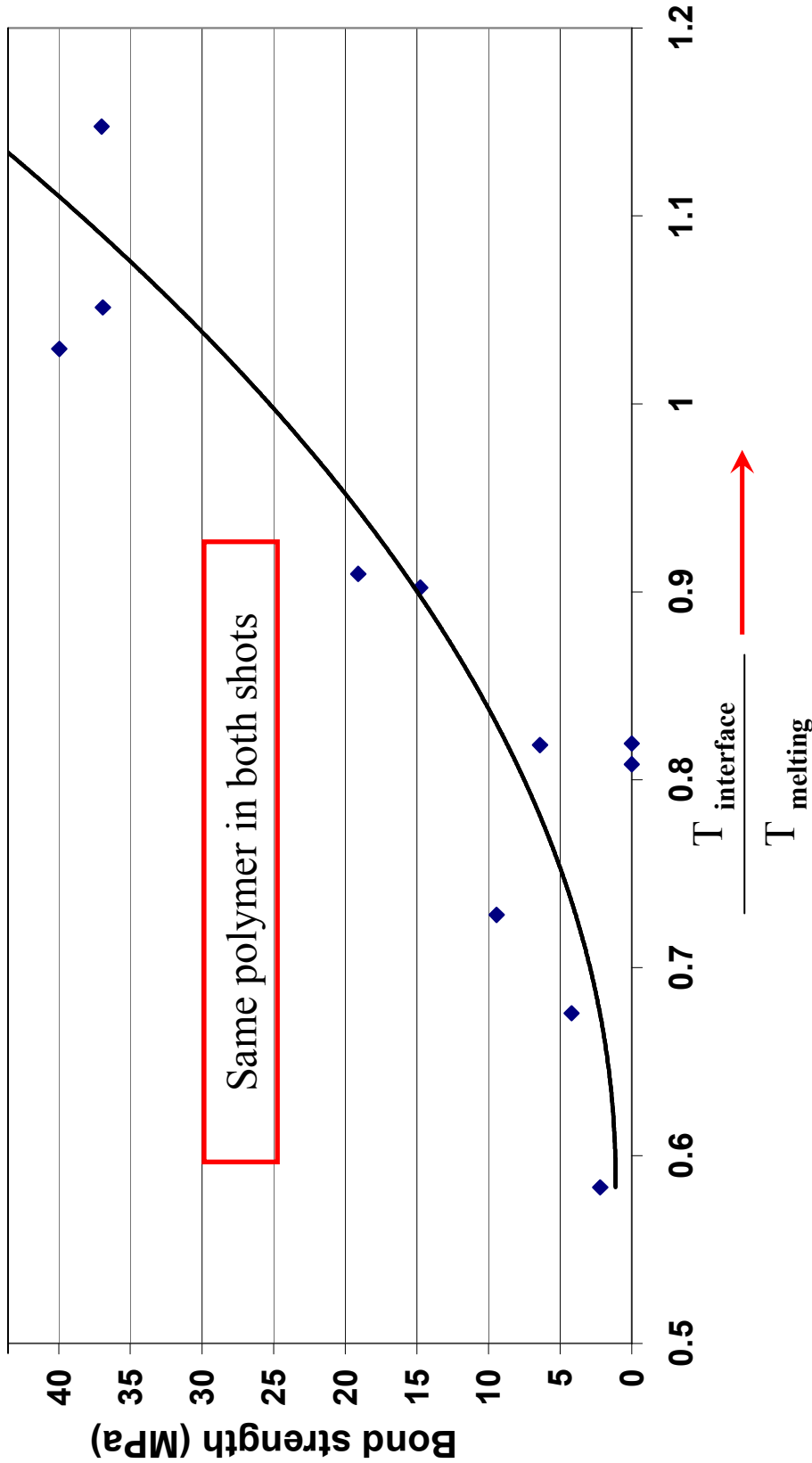
$$T_i = b_1 T_1 + b_2 T_2$$



Good bonding

$$T_i > T_{\text{melting } 1}$$

Effects of interface temperature

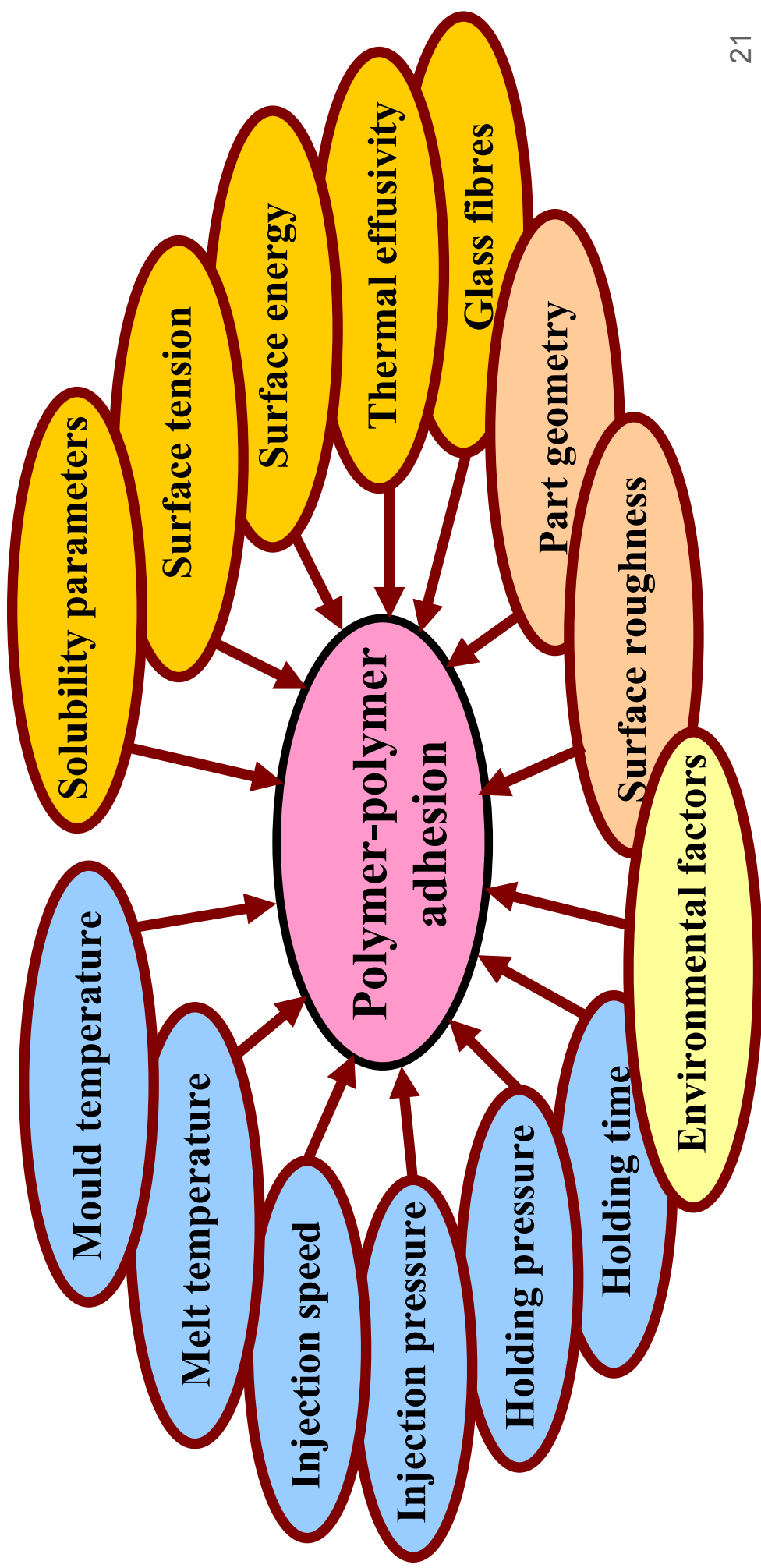


$$\frac{T_{\text{interface}}}{T_{\text{melting}}} = \frac{\text{Interface temperature}}{\text{Melting point of the inlay part}} \geq 1 \quad (\text{For good bonding})$$

Suitable polymer pairs for 2k applications

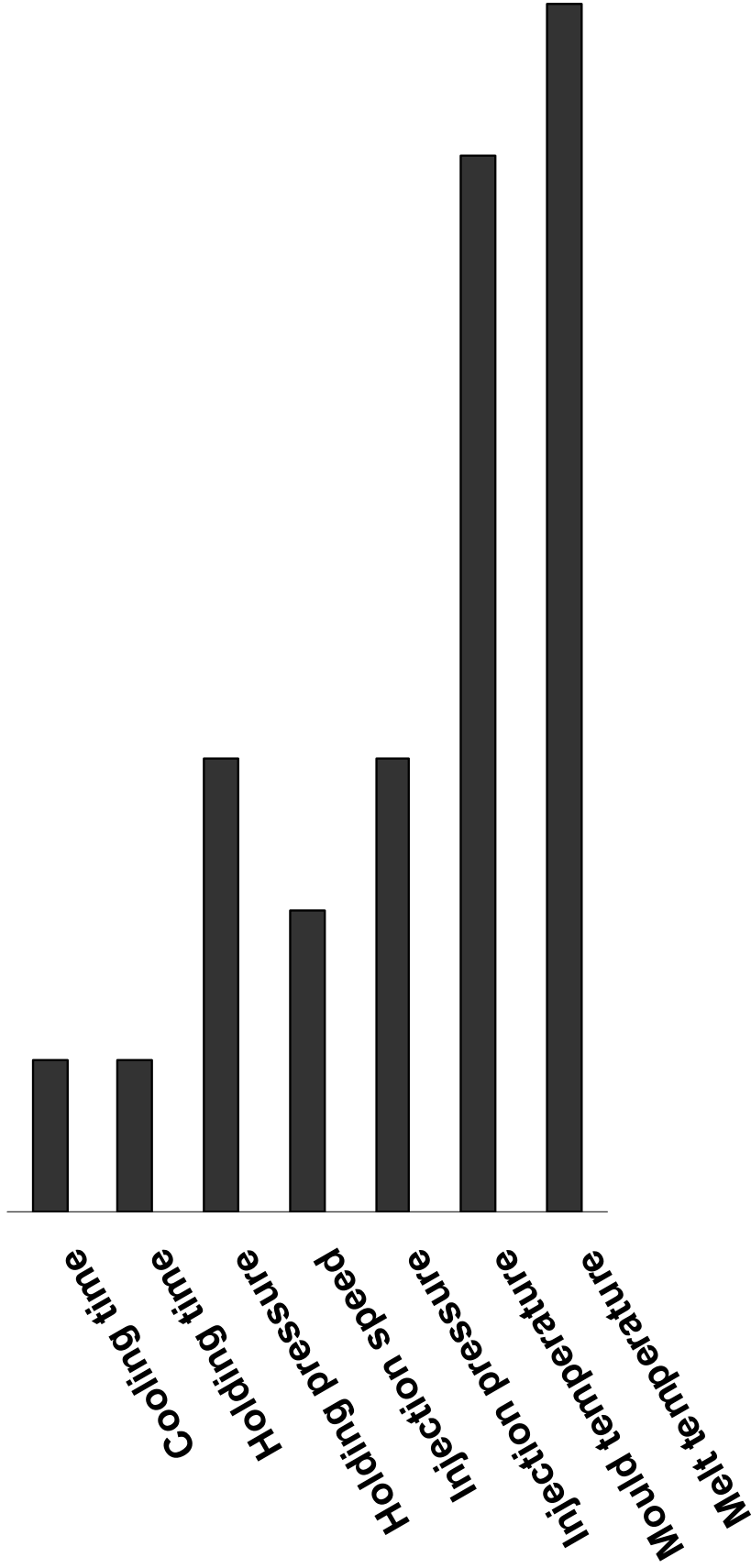
NO	Material pairs (first shot-second shot)	Bond strength with 2k tensile bar (MPa)
1	PEI1000-PEEK	38
2	PC-PEI1000	37
3	ABS-PEEK	30
4	ABS-PEI1000	27
5	PC-PEEK	26
6	ABS-PC	19
7	PEI2312-PEEK	18
8	PC-PEI2312	18
9	ABS-PEI2312	17
10	PS-PEI2312	13
11	PS-(PPE+HIPS)	12

Investigations of the factors affecting polymer-polymer bond strength

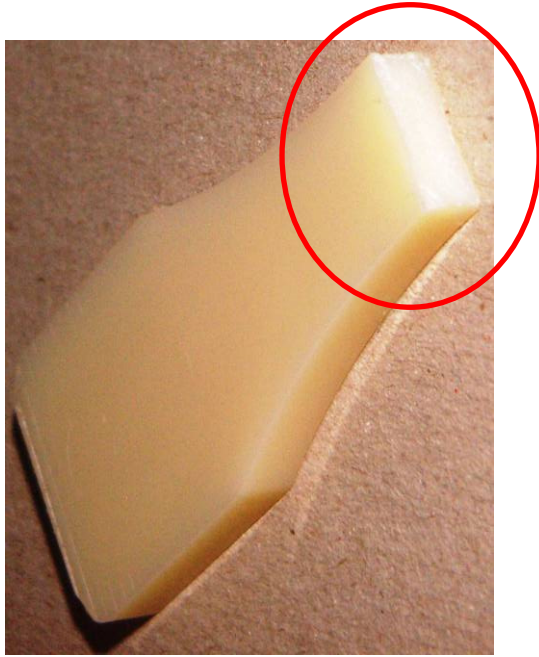


Effects of injection moulding parameters on bond strength

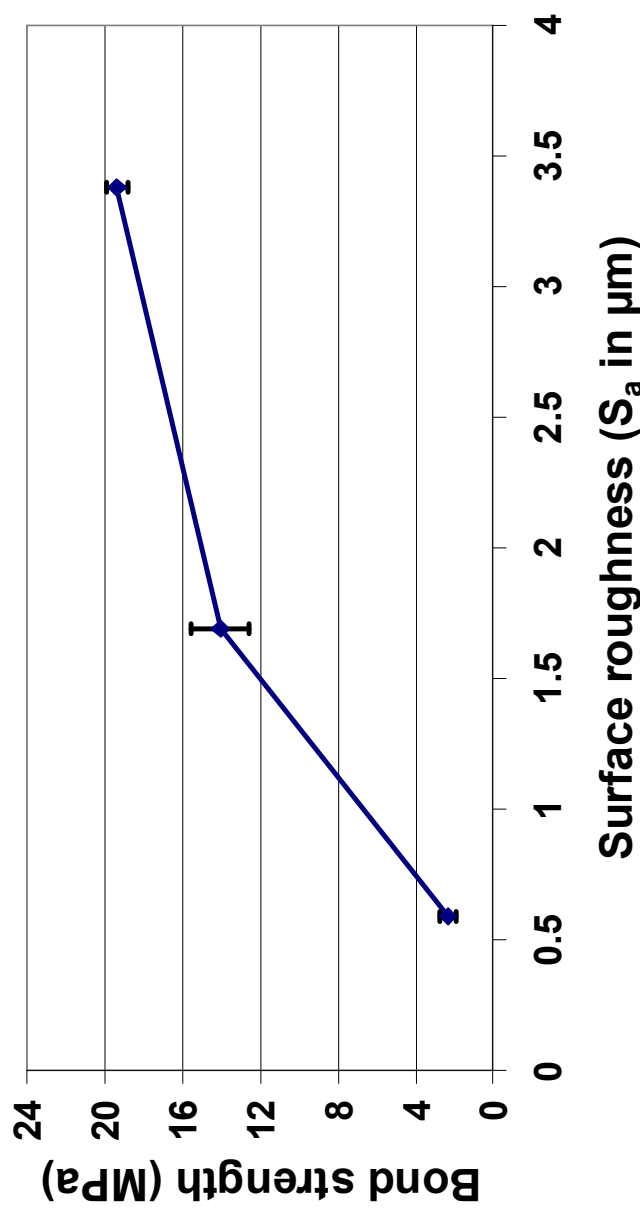
Comparative influence of injection moulding parameters on the bond strength

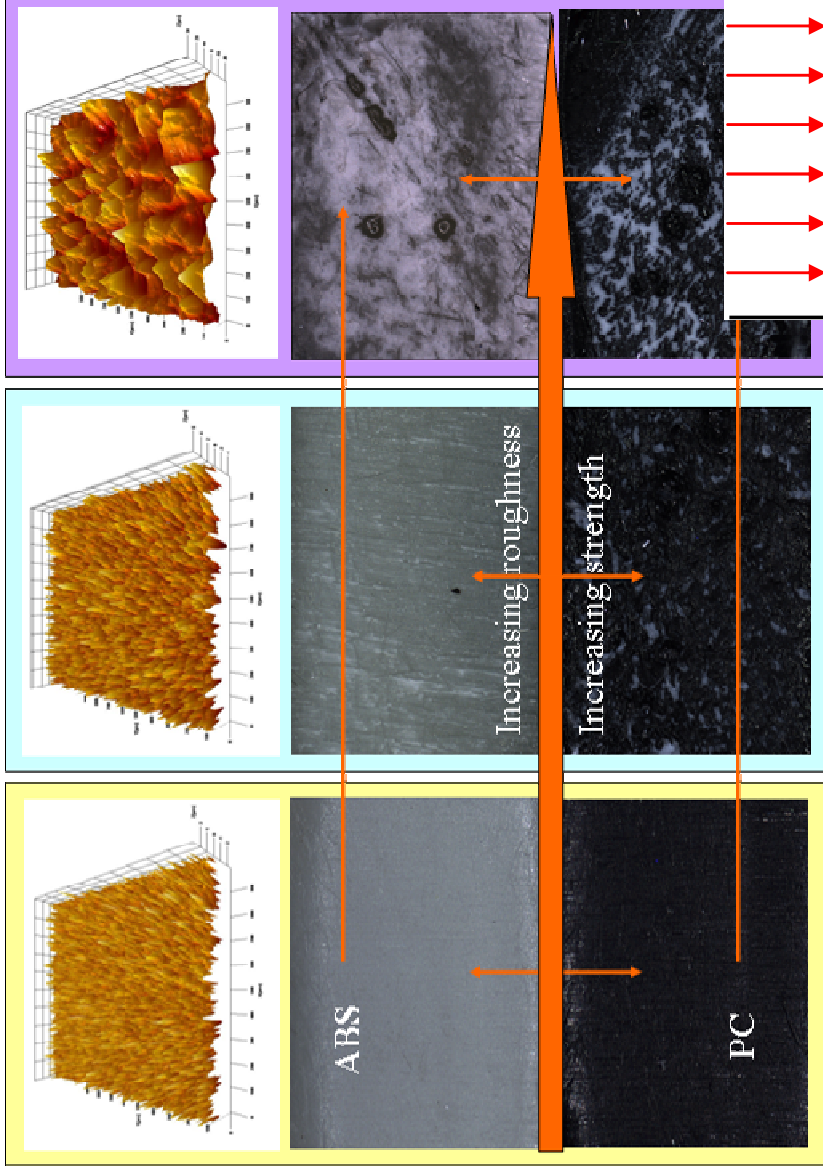


Effects of surface roughness



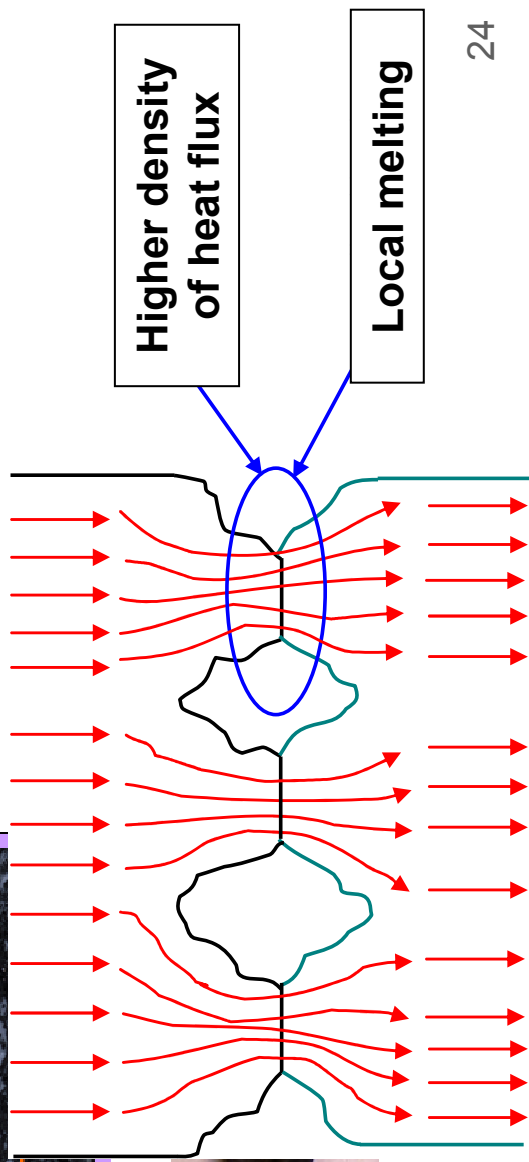
Bond strength vs. surface roughness





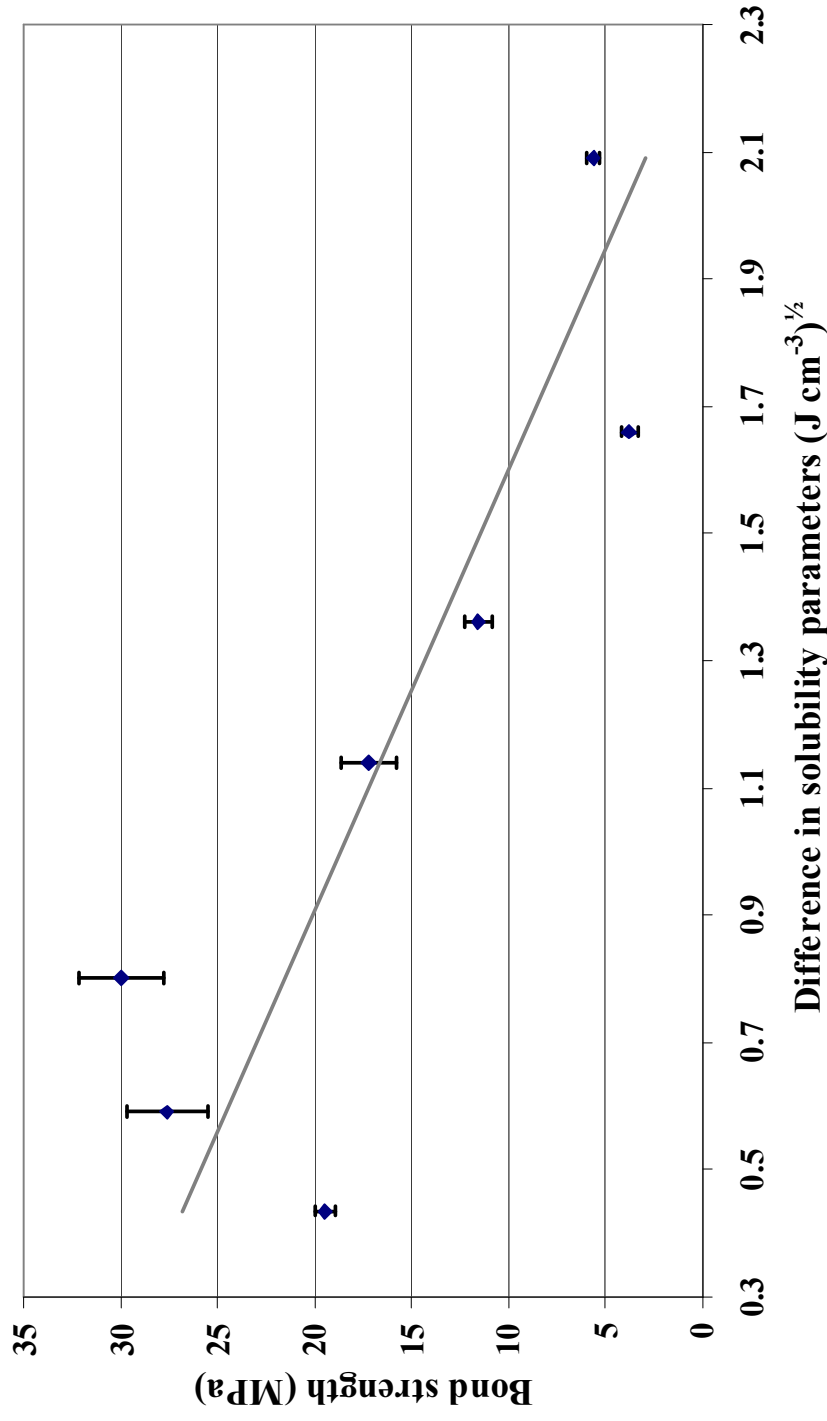
Effects of surface roughness

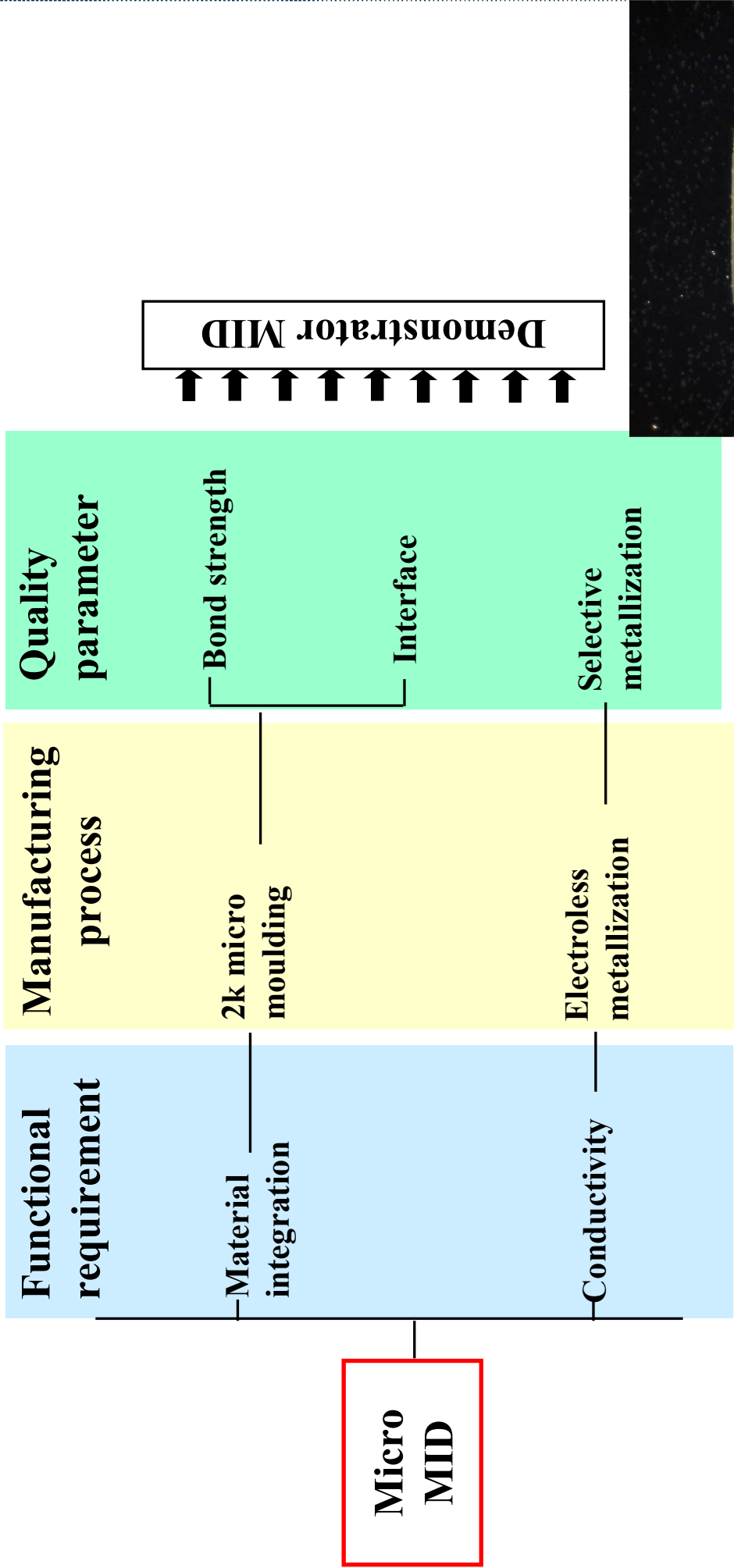
- Mechanical locking
- Increased area
- Localized melting (high surface area to volume ratio)



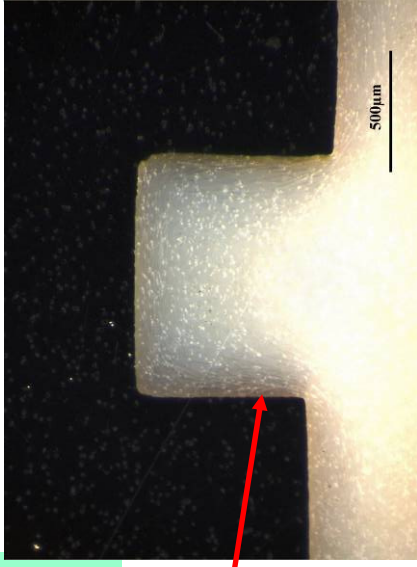
Effect of solubility parameters on the bond strength

- Characteristic of a polymer used in predicting the solubility of that polymer in a solvent

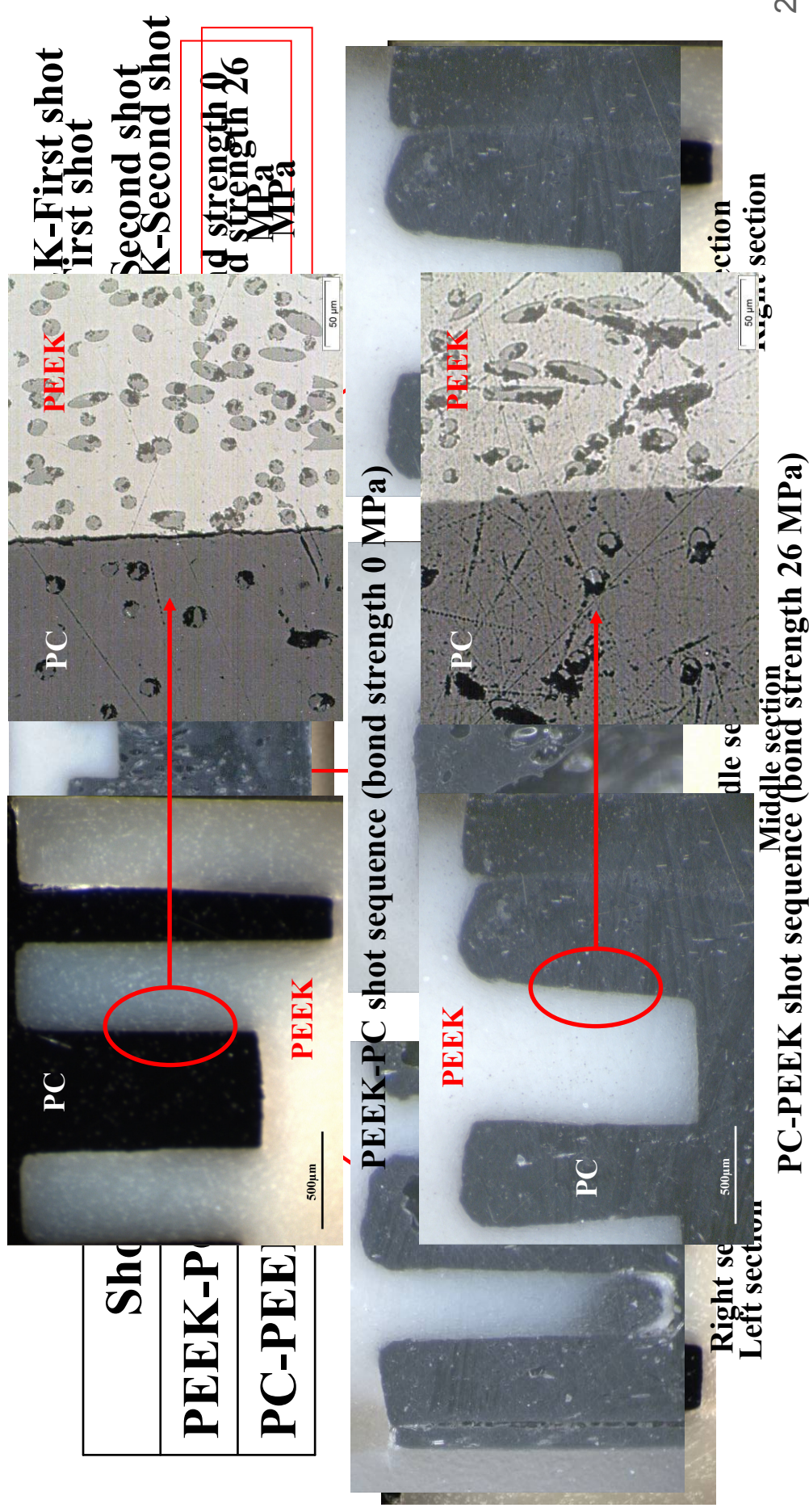




Interface of two polymers

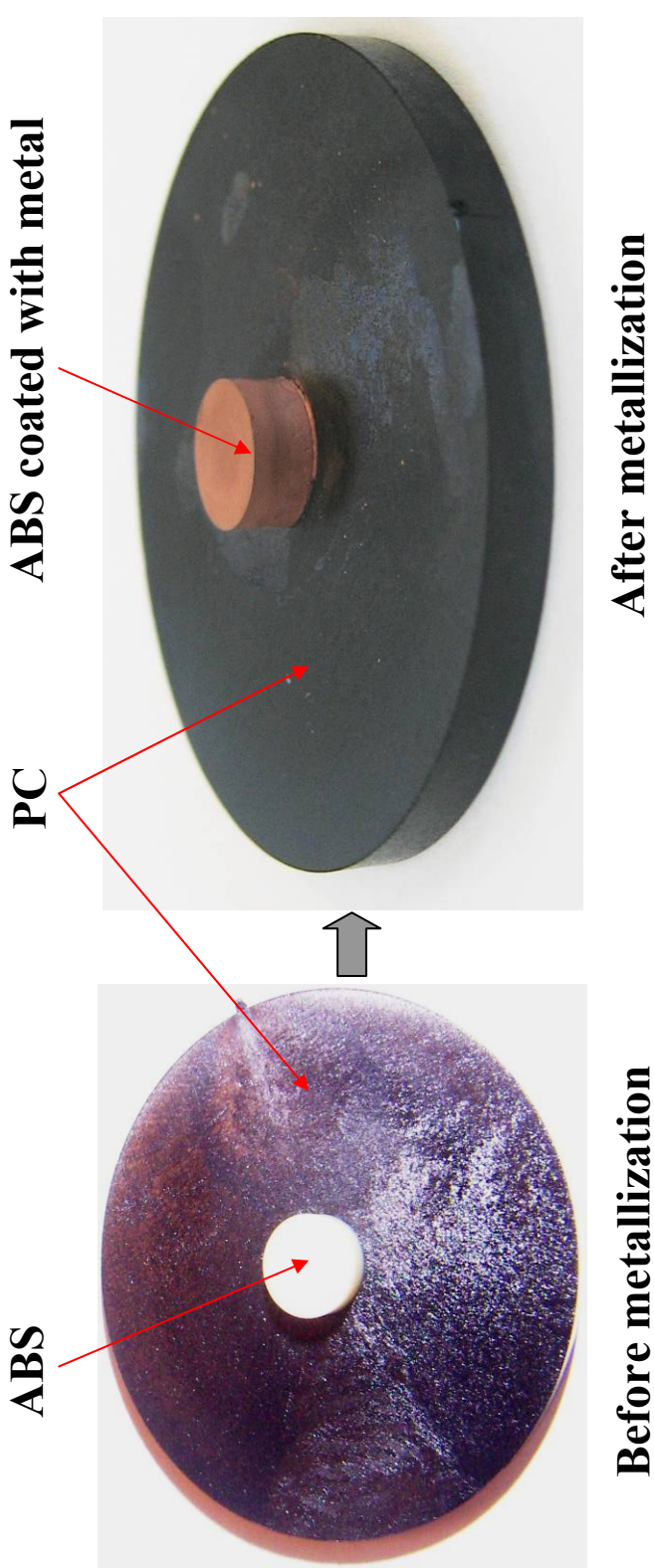


Polymer-polymer bond strength and interface dilemma



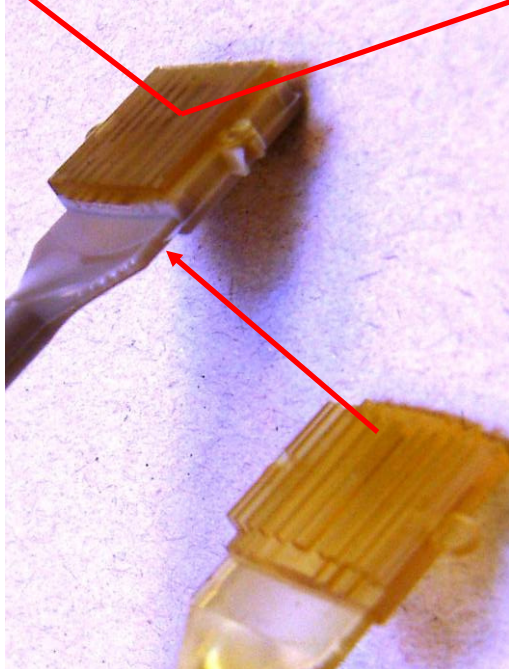
Selective metallization

Polymer pair	Metallized polymer
ABS-PC	ABS
PEI1000-Noryl GTX810	Noryl GTX810
PEEK- Noryl GTX810	Noryl GTX810



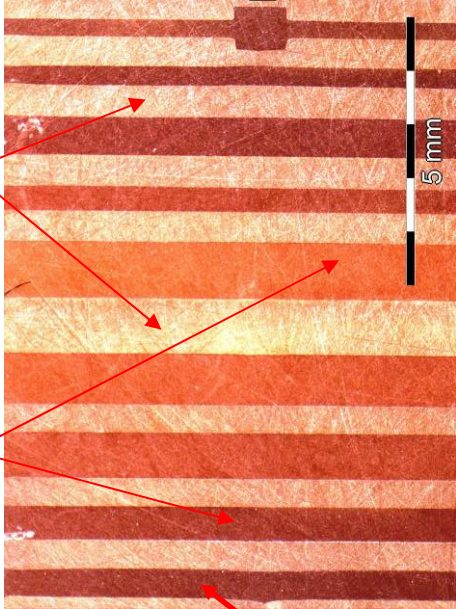
PEI1000-Noryl GTX810

PEEK-Noryl GTX810



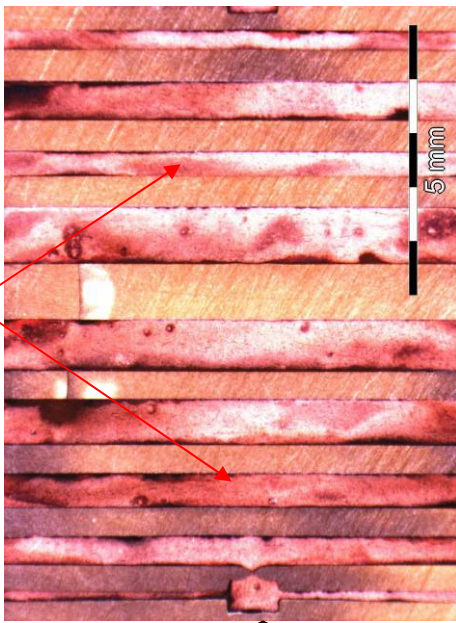
Noryl GTX810

Ultem PEI1000



Before metallization

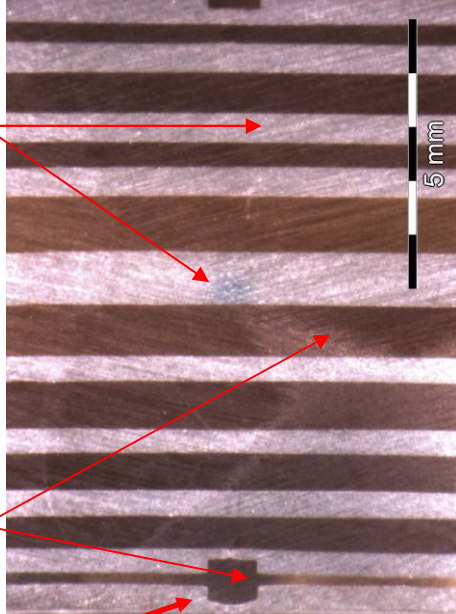
Noryl GTX810 coated with metal



After metallization

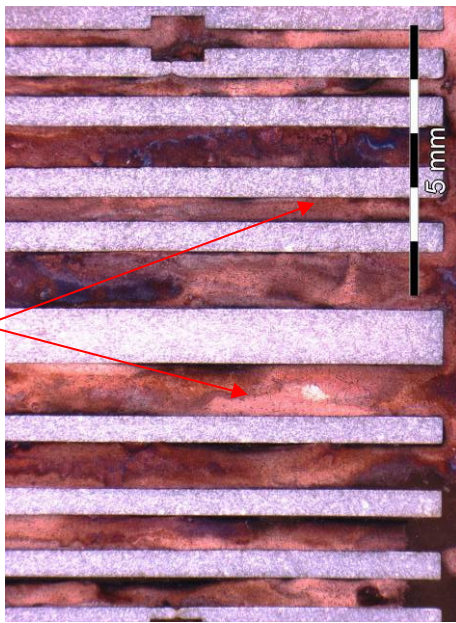
Noryl GTX810

Victrex PEEK150



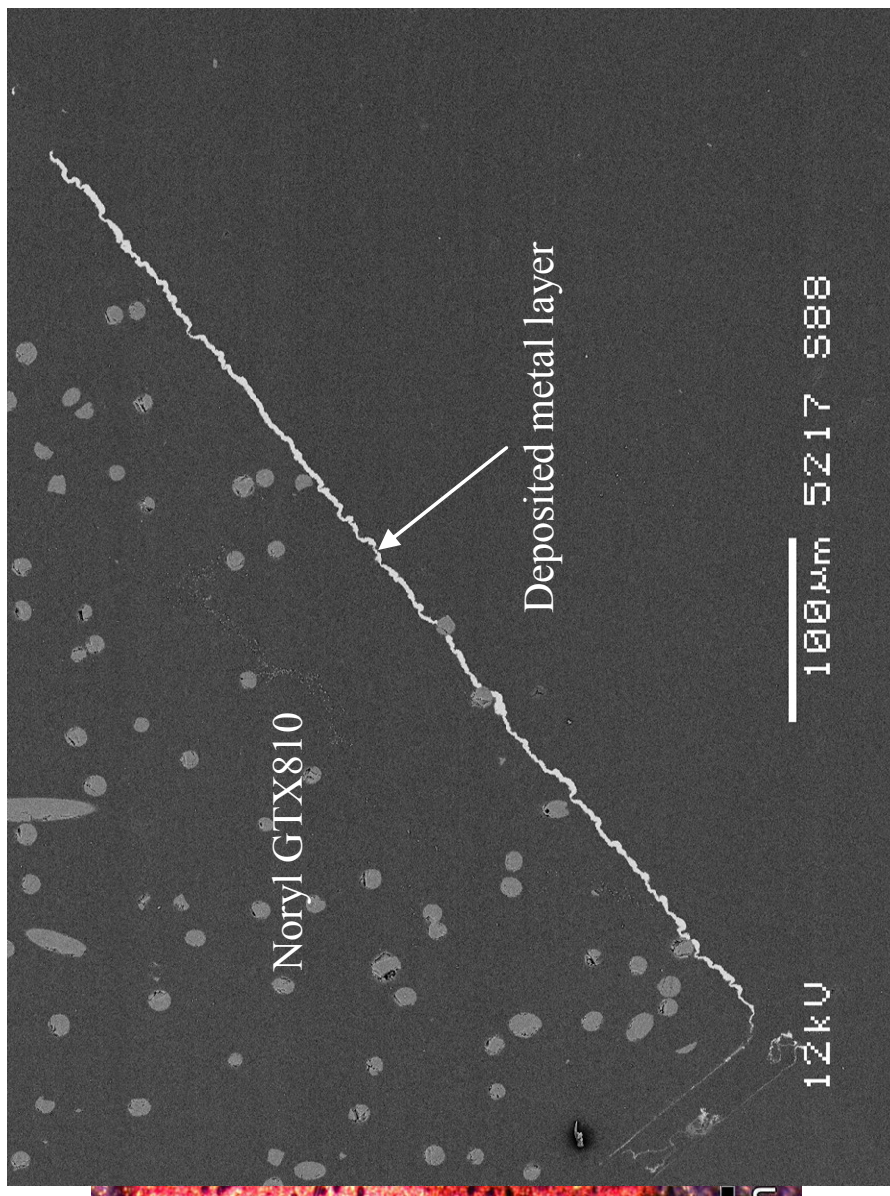
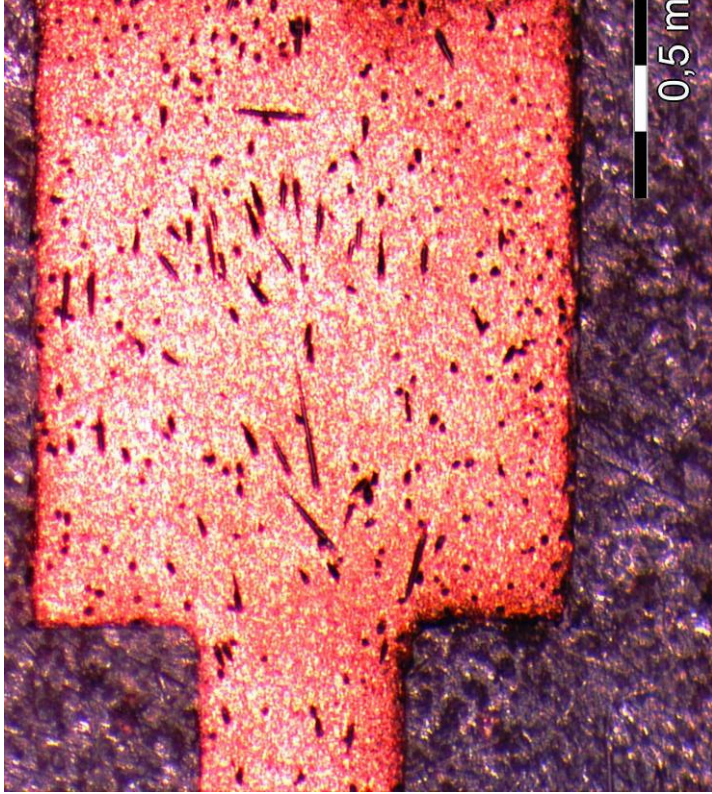
Before metallization

Noryl GTX810 coated with metal

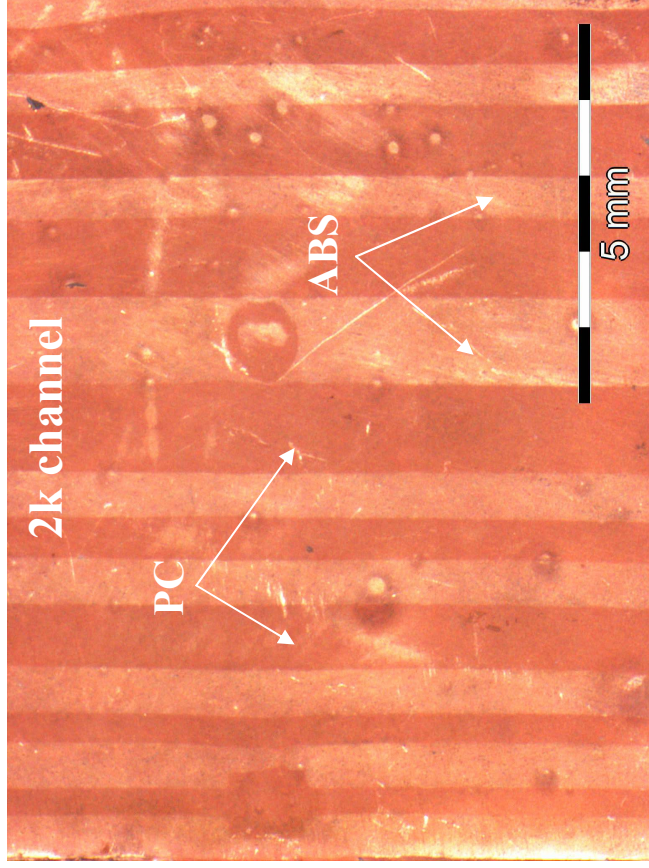


After metallization

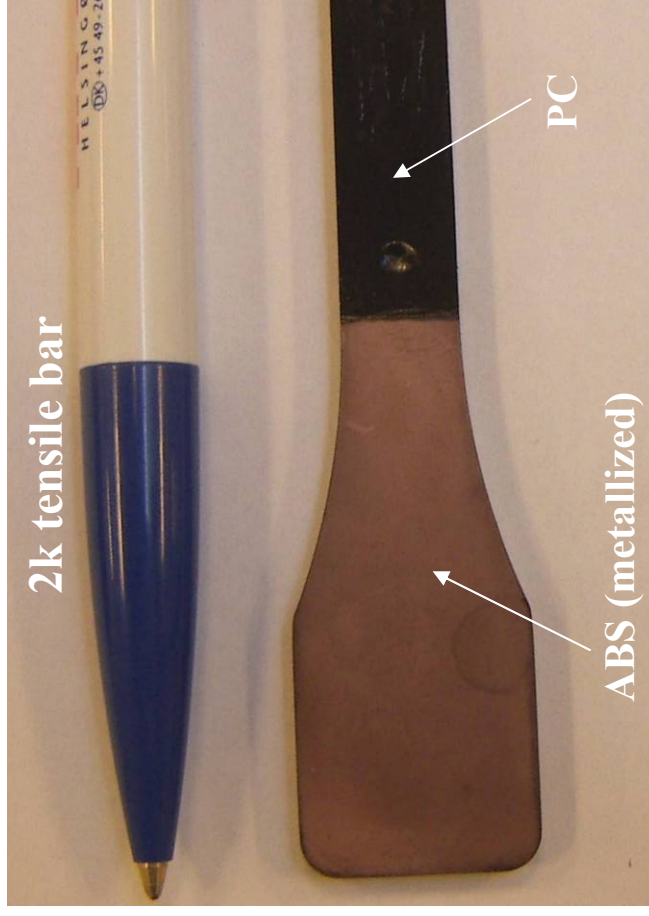
Selective metallization



Difficulties in selective micro metallization

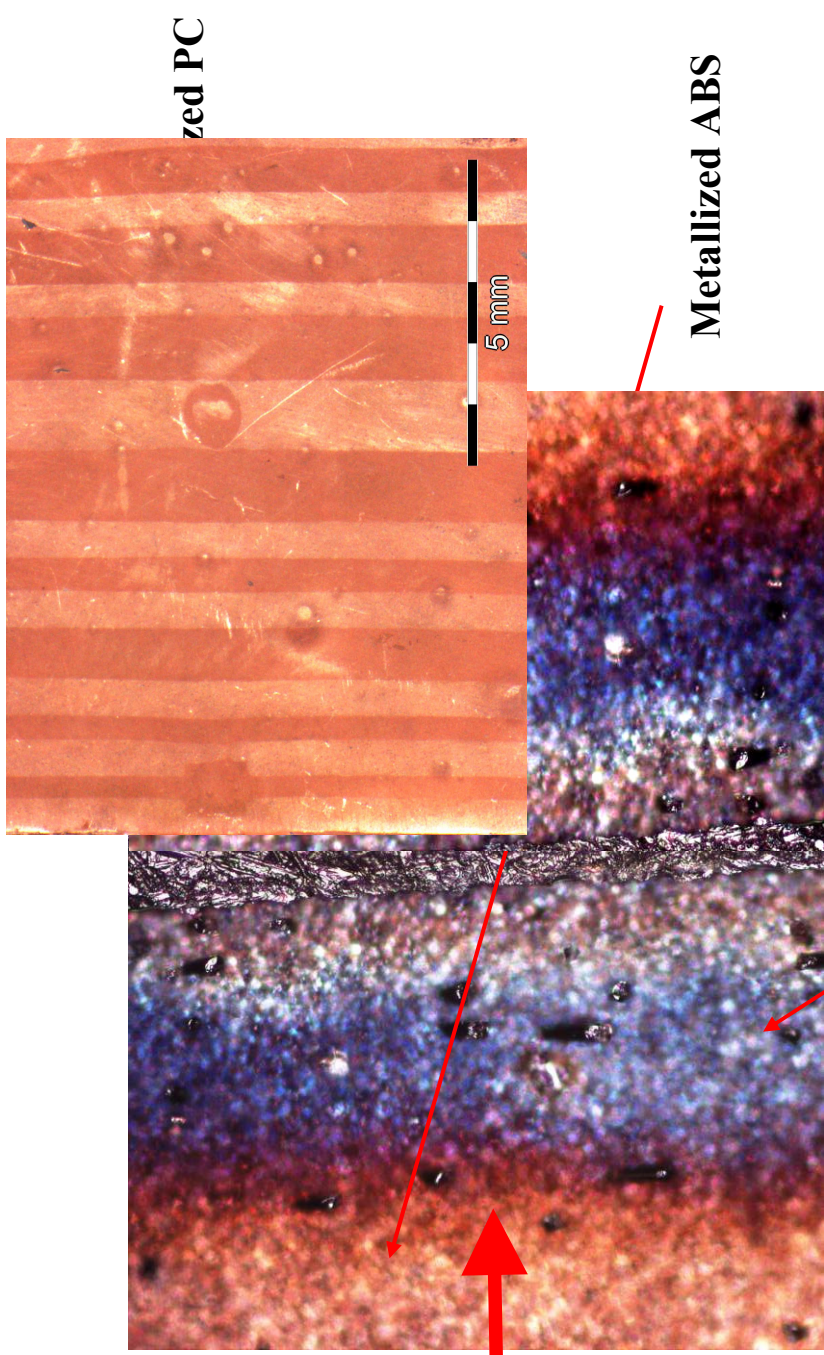
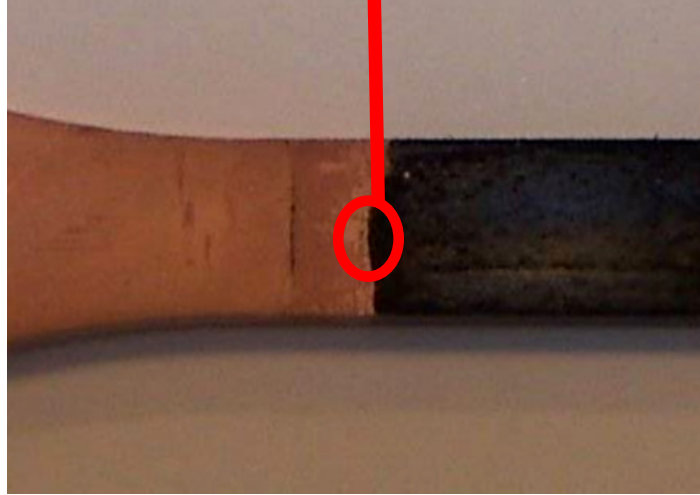


ABS-PC part after metallization



ABS-PC part after metallization

Intermediate zone of metallization



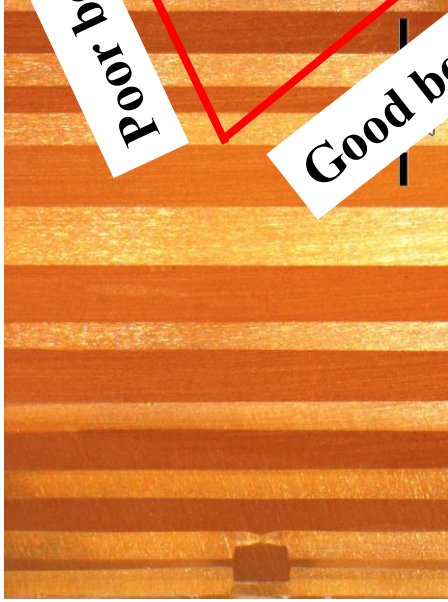
Mixing zone (partially metallized)

Metallized ABS

Metallized PC

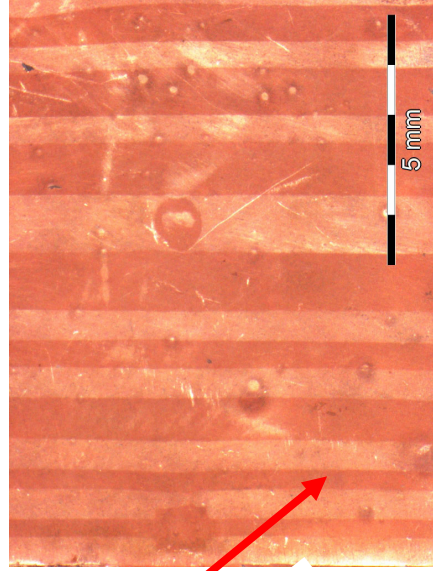
Interface quality and selective metallization

PEI1000-GTX 810



-Polymer not mixing at the interface (bond strength 3 MPa)

-Selective metallization



ABS-PC

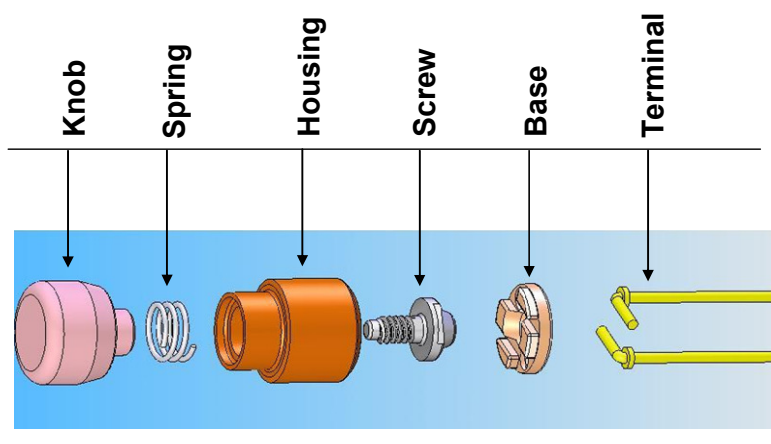
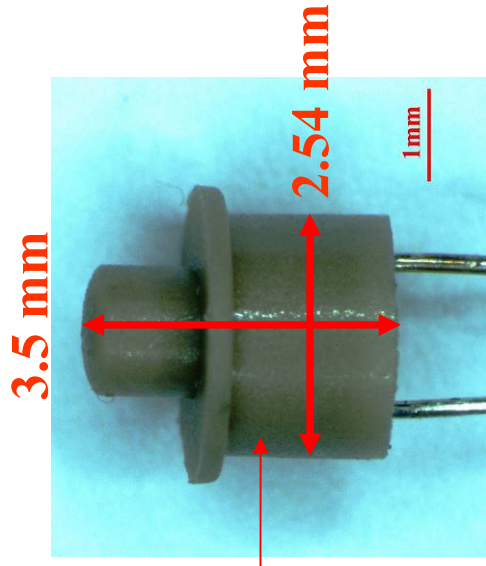
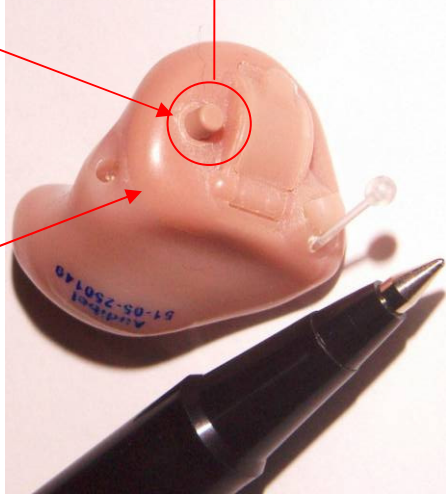
-Polymer mixing at the interface (bond strength 19 MPa)

-Non-selective metallization

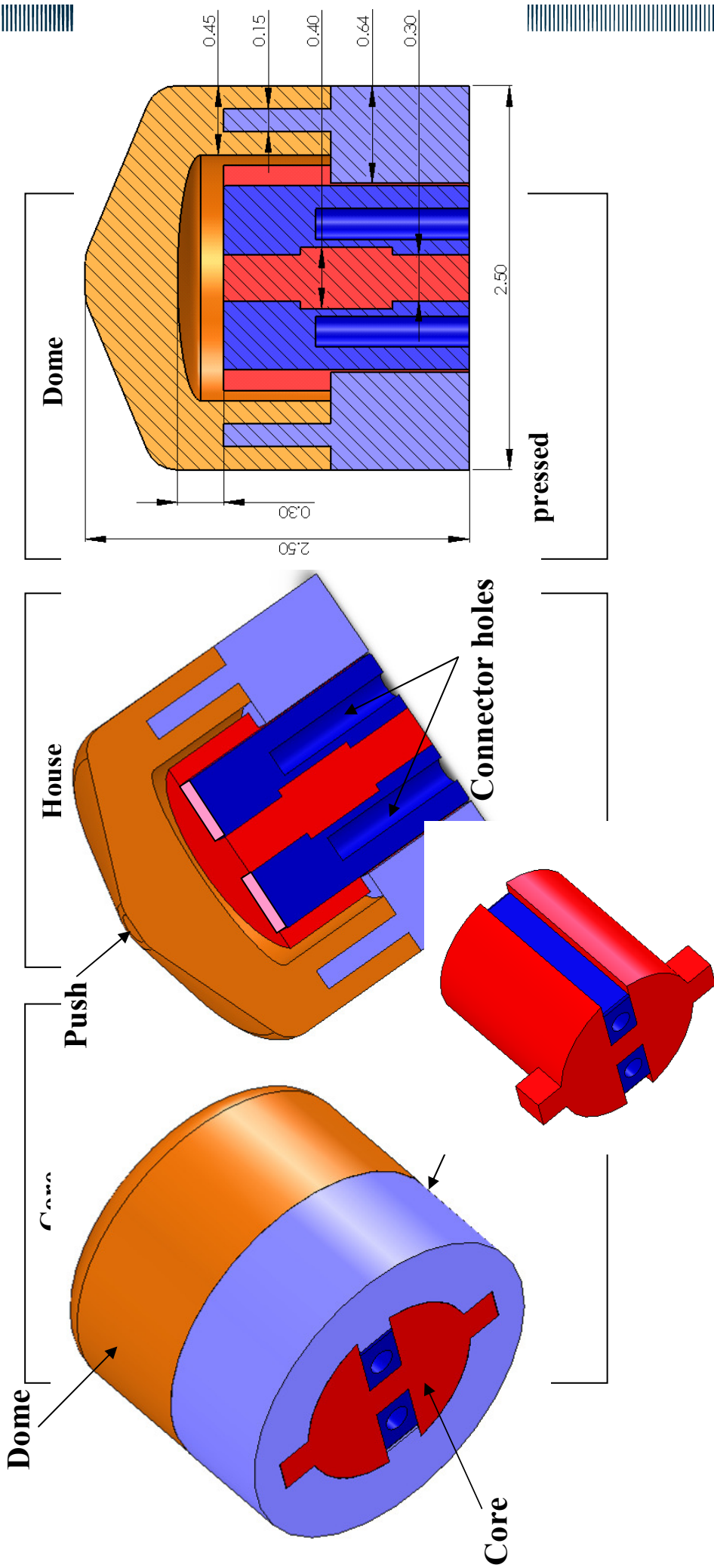
Demonstrator MMD

- On-off button used in hearing aid by Pulse ApS

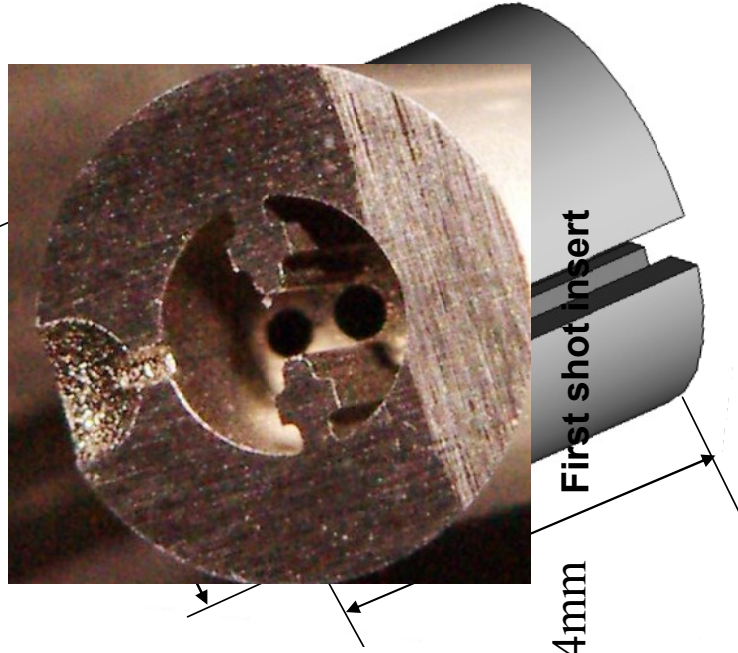
Hearing aid On-off button



New concept of push button



Selected demonstrator geometry (push button core)



Second shot

-Design

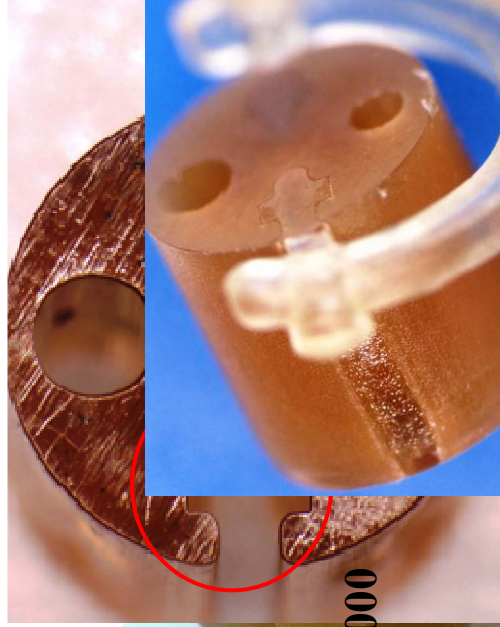
-Tooling

-Injection moulding

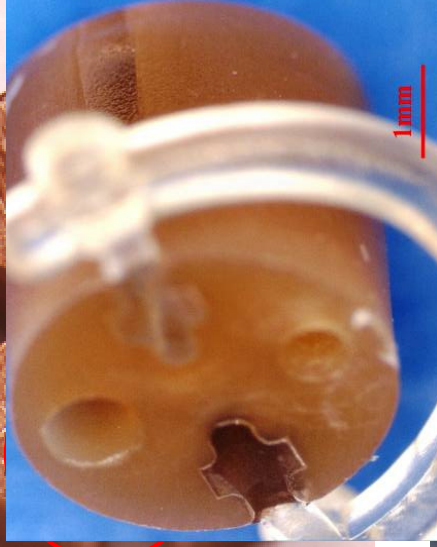


Part after second

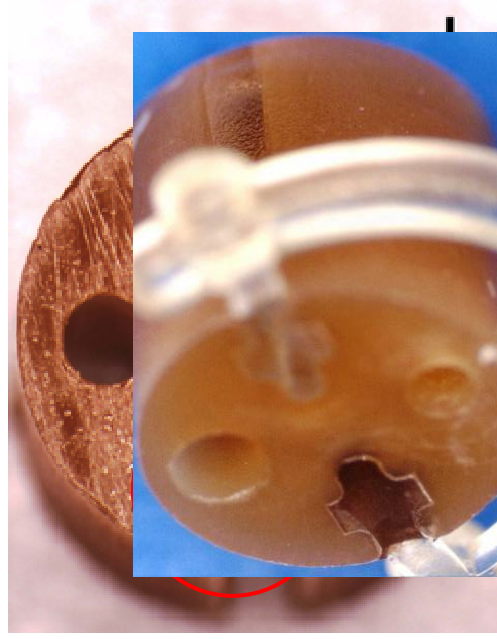
Injection moulding



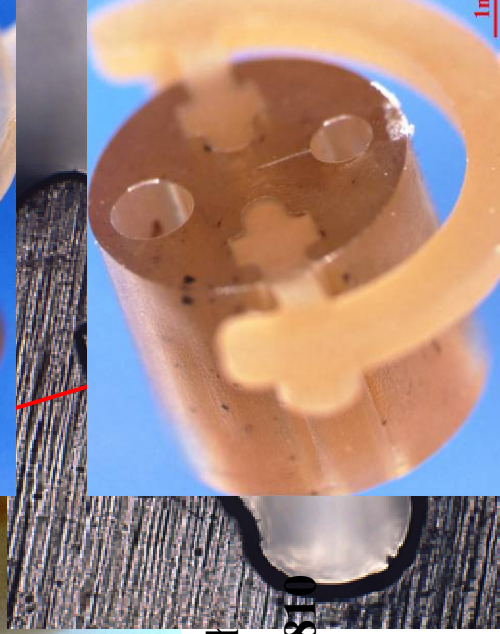
Ultem PEI 1000



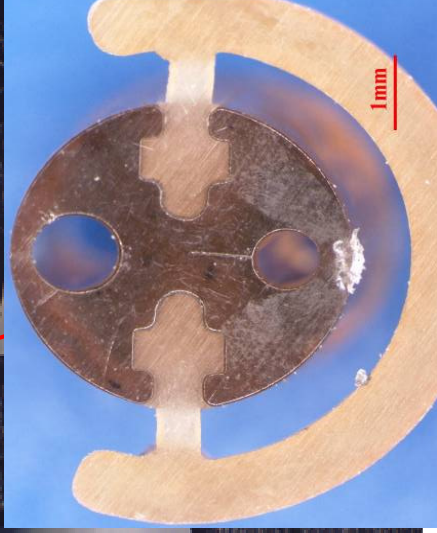
GTX 810-PEI1000



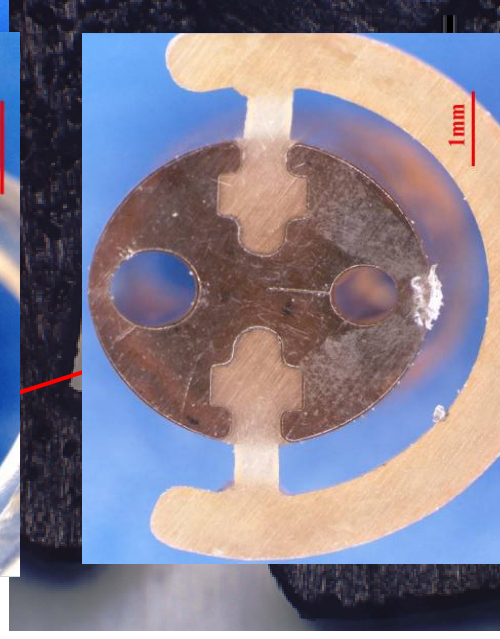
Noryl GTX 810



1st sl

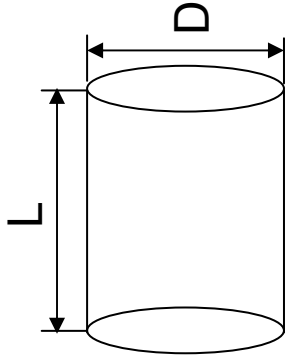


PEI1000-GTX810



GTX810

Metallization



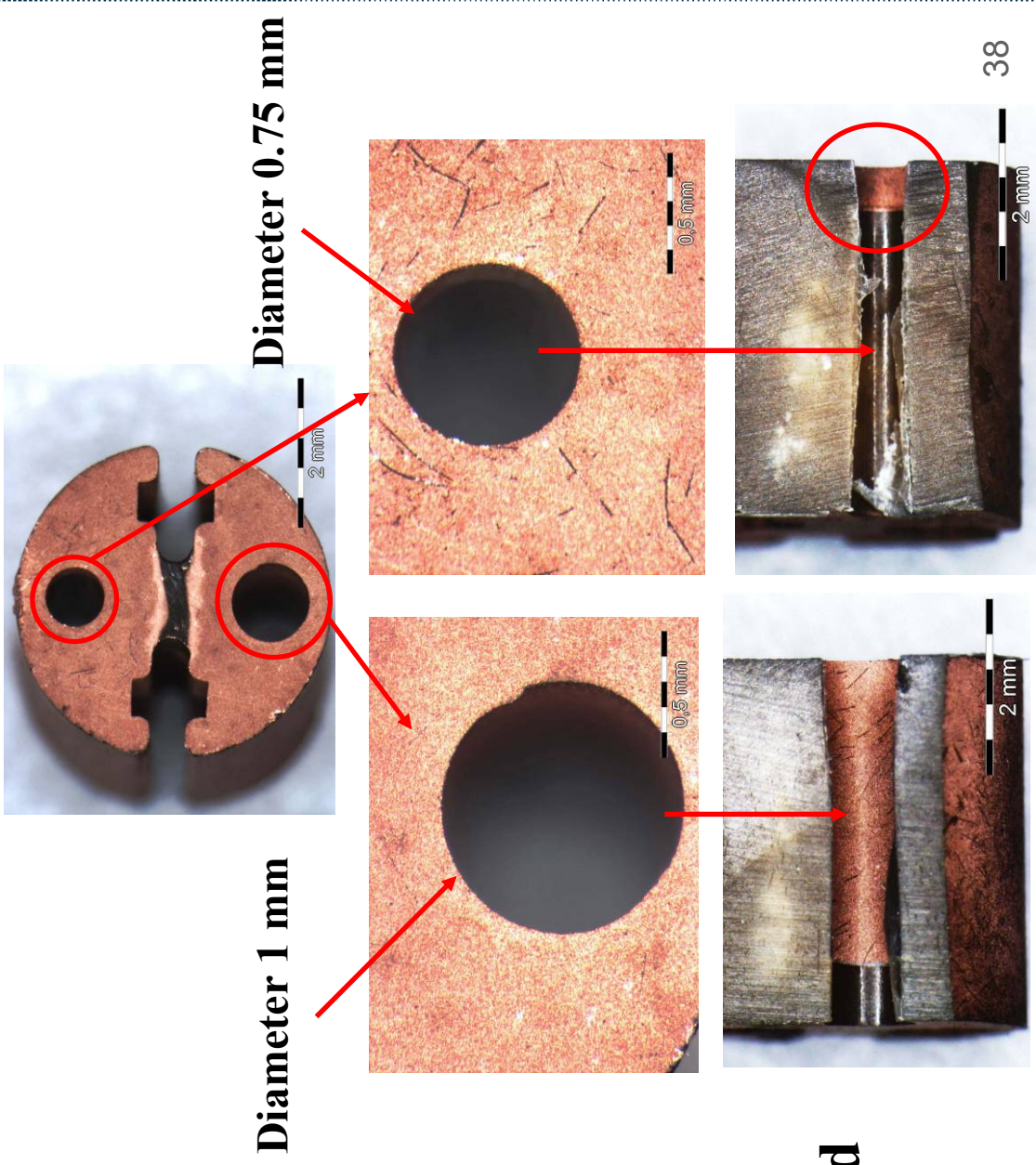
Through hole plating

-Trapped air and chemicals

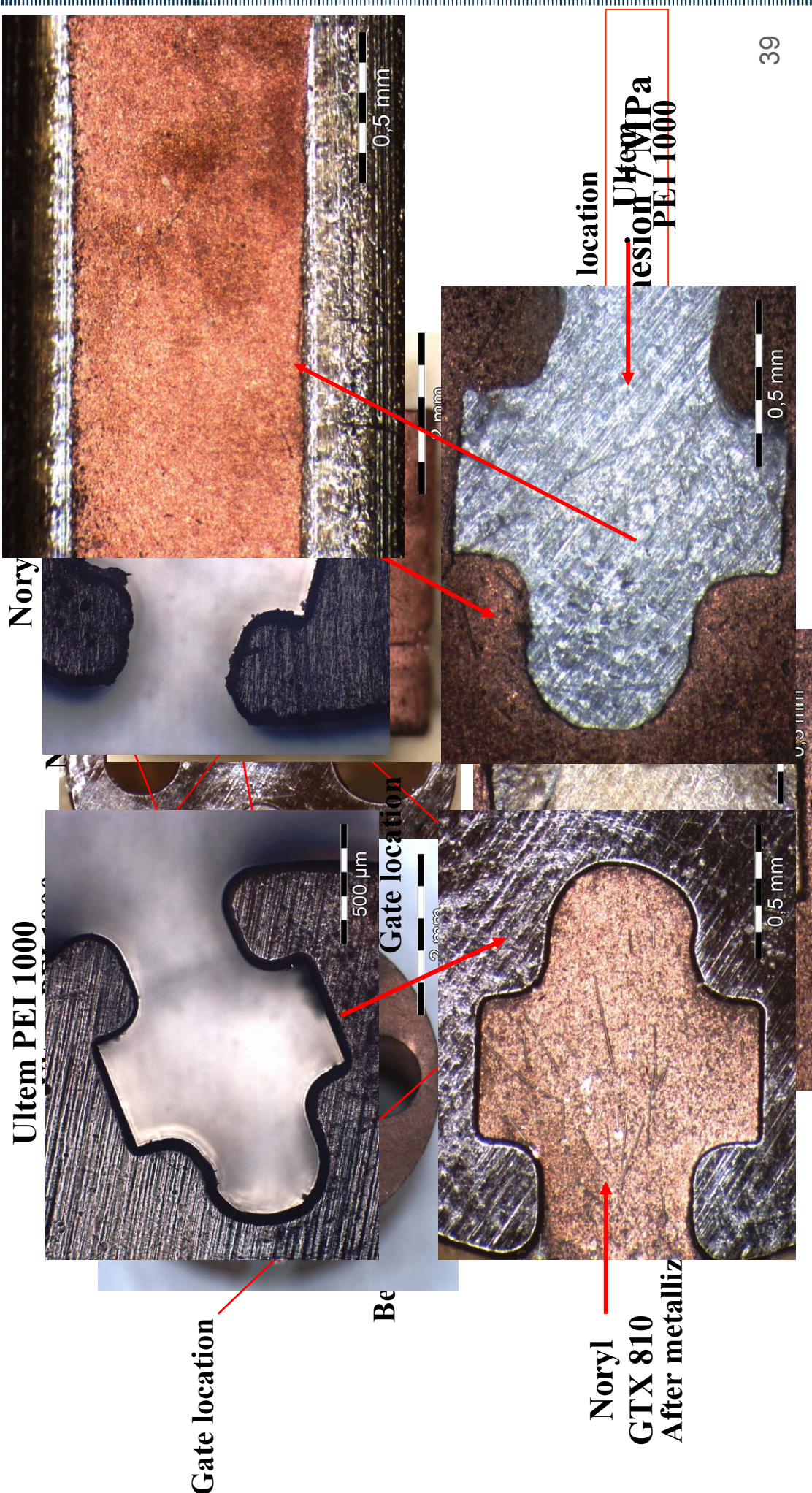
-Length/diameter ratio (L/D) is critical

-Optimization is required for higher L/D ratio

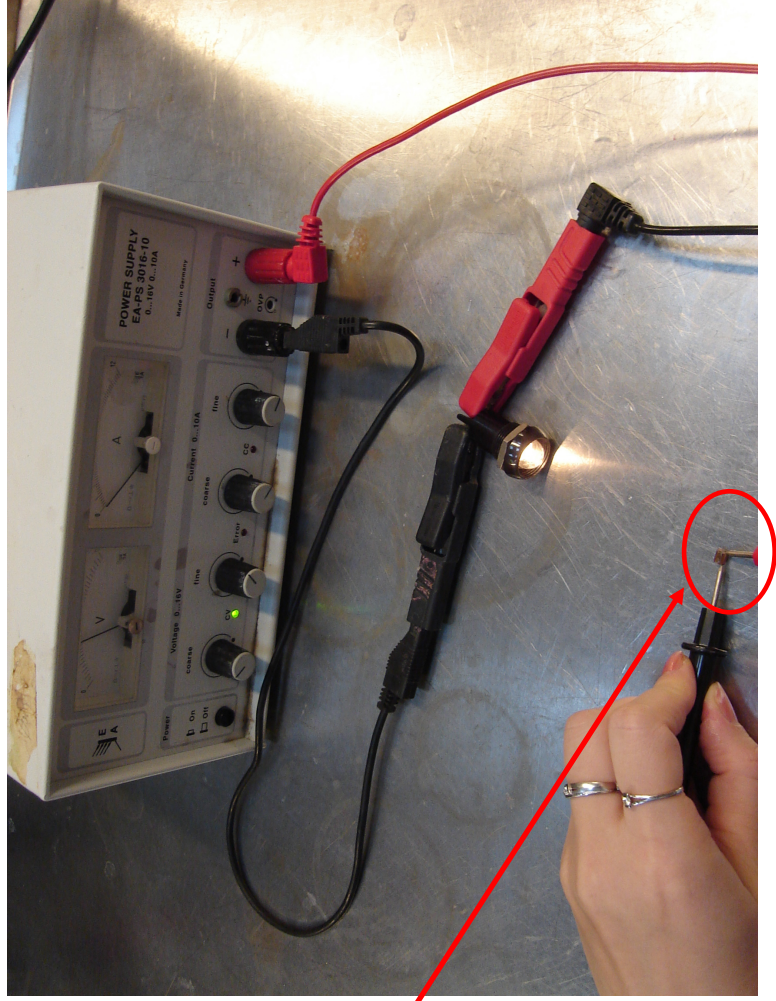
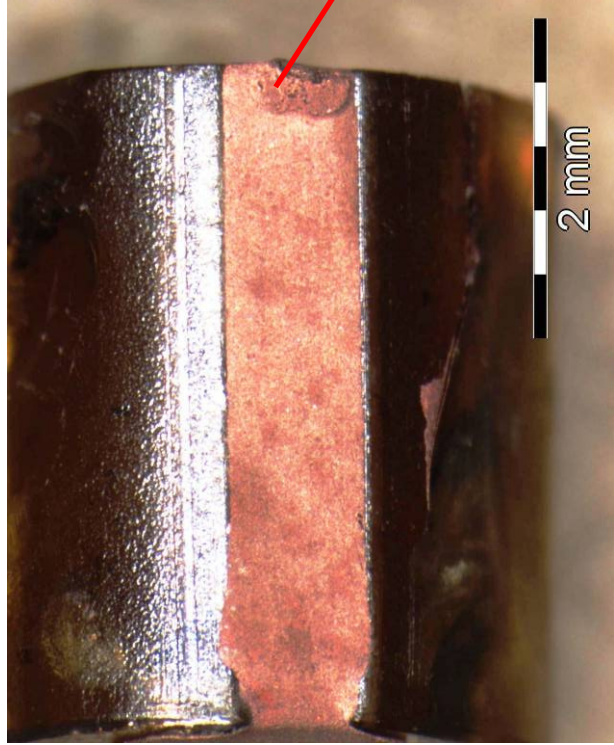
Noryl GTX810 1k part (Metallized)



Selective metallization



Electrical testing



Summary and conclusion

- 1. New material pairs for 2k applications and also for MID applications. LCP, POM proved unsuitable for 2k micro moulding and micro MIDs**
- 2. Important factors for bond strength: Injection parameters, interface temperature, material shot sequence, substrate surface roughness, environmental conditions**
- 3. Polymer-polymer interface study, effects of various parameters on the interface, relation between the bond strength and interface of two polymers**

Summary and conclusion

- 4. Several new material pairs for selective metallization were identified. Factors affecting the metallization quality of plastic parts investigated**
- 5. Demonstrator MID fabricated with the knowledge gained from the project proved its feasibility for industrial applications**

Thank you for your attention